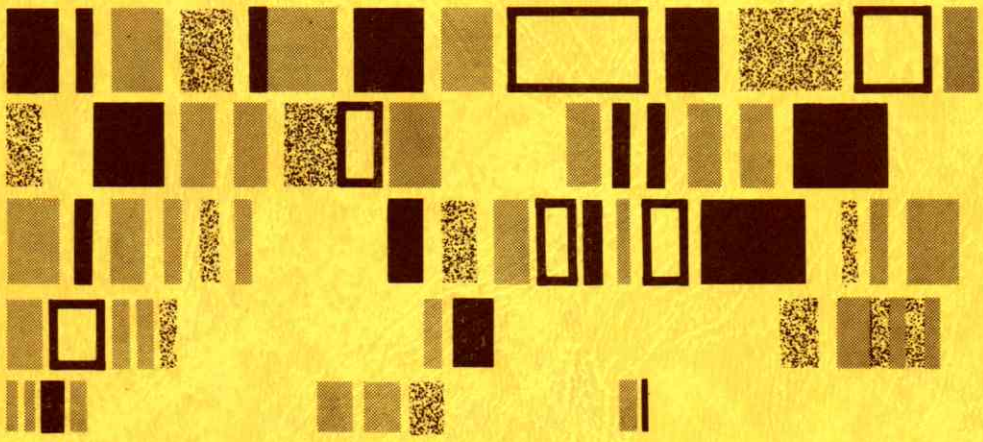
SECOND NATIONAL SYMPOSIUM ON ENGINEERING INFORMATION

A COORDINATED ENGINEERING INFORMATION SYSTEM



ENGINEERS JOINT COUNCIL

ENGINEERS JOINT COUNCIL

Engineers Joint Council is a federation of engineering societies with a combined membership of 500,000, having as its principal objectives:

a. to advance the art and science of engineering for the general welfare of mankind;

b. to promote cooperation among the various branches of engineering;

c. to develop recommendations regarding public policies wherein the application of the art and science of engineering will contribute to the general welfare of mankind;

d. to conduct research and studies in engineering areas and to promote dissemination of knowledge and information on the various fields of engineering.

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Second National Symposium on Engineering Information

THEME: A COORDINATED ENGINEERING INFORMATION SYSTEM

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Foreword

The papers in this publication were presented at the Second National Symposium on Engineering Information held on October 27, 1965 at the Hotel Roosevelt in New York, N. Y.

In January 1962, Engineers Joint Council held its First National Symposium on Engineering Information. Representatives from engineering societies, industry, universities, and government attended the meeting and participated in the development of an information systems action plan. Implementation of the plan resulted in publication in 1964 by EJC of the "Thesaurus of Engineering Terms," an engineering vocabulary reference relating the terminology in all major fields of engineering. The plan also called for greater participation by authors and editors to aid in later retrieval of technical papers by indexing them at the time of original publication. In 1965, more than 4000 technical papers published by engineering societies will have been indexed at source according to the EJC plan.

The next phase of the action plan was presented at this symposium. It calls for the establishment in the near future of a united engineering information system using as components, information systems developed by individual engineering societies coupled to the expanded facilities of Engineering Index, Engineering Societies Library and American Society for Metals Documentation Service and coordinated with information programs of government agencies.

A Tripartite Committee representing Engineers Joint Council, Engineering Index and United Engineering Trustees (of which Engineering Societies Library is a component) is developing the policies and planning the organizational structure of a coordinated engineering information system.

Chairman of the Symposium Committee was John McGowan, Director of Libraries, The Franklin Institute, and chairman of the EJC Committee on Engineering Information. Serving with Mr. McGowan on the Symposium Committee were Bart E. Holm, E. I. du Pont de Nemours & Co.; Morris Rubinoff, University of Pennsylvania; Robert M. Bowie, Board member, United Engineering Trustees and Engineering Societies Library; Frank Y. Speight, Director of Information Program, Engineers Joint Council; and Norman E. Cottrell, Chairman, EJC Information Systems Committee.

Session Chairmen were Dr. Ernst Weber, president of Polytechnic Institute of Brooklyn and Robert B. Smith, Director of Information Services, Eastman Kodak Company.

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Introduction

BY WALKER CISLER[1]

I am delighted to welcome you to this Second National Symposium on Engineering Information which will discuss one of the most pressing intellectual matters of our day, certainly one that has an important meaning for the future of the engineering profession.

Today we have more scientists and engineers than ever before, and increasingly large sums of money are being invested in facilities for research and development. Whereas Isaac Newton might say that his accomplishments were possible because he stood on the shoulders of giants, and if he had cared to, he could have named them individually, our endeavors are now carried forward on a much broader scale, by great numbers of individuals and institutions.

We live in one of the great ages of discovery, a turning point in human affairs that we cannot fully evaluate because we are in the center of what is going on. We only know that in technology, science, and engineering, we have put together a mechanism of extreme power and productivity that is changing the fundamental relationships between individuals, human institutions, and even nations. Potentialities are immense for accomplishing what has never been possible before.

As many of you know, my life work has been in the field of energy and power for now more than 43 years and I have seen firsthand the working of these new forces in many nations of the world — in nations which are well advanced industrially and in those which are now seeking industrial development and higher productivity. I have become ever more keenly aware of the ability of scientists and engineers to set up situations and then to find the solutions. And I have given much thought to the need for sound management in meshing the gears effectively so that there can be orderly growth and an efficient utilization of brain power, facilities, and investment.

May I tell you just a little story? After the end of the war in Europe and at the beginning of the period of the Marshall Plan, I was told by my friends there — and these were people of importance in the different nations — that they were concerned as to whether they could continue to look to the West for great engineering accomplishments. They had seen firsthand the results of our tremendous ability to produce, the equipment and materiel of all kinds. But they were concerned as to what we were saying about our engineering education and the relatively small number of engineers graduating from engineering and technical schools. And so they said, "Must we now look to the East for the future of engineering and scientific accomplishment?"

I advised then not to worry, because the hard core of science, technology, and engineering remained firm in the United States; that engineering education would continue on its accelerating scale; and that in the engineering organizations in the United States there was this great body of experienced people to which was being added large numbers of younger people. And I thought to tell you the story because this was a real concern in Western Europe in those days. I think our coming together here is proof that we are still making progress.

Clearly, we must manage well the superabundance of information that scientific and engineering endeavors are bringing forth. This great mechanism does not have at present a very high order of efficiency. The problem which we face — and which is discussed in this symposium from many points of view — is how we can effectively and promptly, make the accelerating collection of information available to all who have the need, so that the same particular results need not be developed again and again by different individuals and organizations.

While this is clearly a matter of great concern to scientists and engineers, it is equally important to those who have responsibility for the management of affairs in industry and government. The production and utilization of information in the overall sense requires careful management. This task brings all of us together on a common ground and I am confident that we can do much about it. What we have here is a process, a system, and we certainly know how to analyze and apply technology and management know-how to processes of many kinds. It is good to know that the United Engineering Trustees, the Engineering Index, the Engineers Joint Council, and other organizations are working together on these matters. In this manner a considerable amount of experience and many points of view can be brought into focus.

We recognize, of course, that the problem is complex and that we must move forward, step by step, in a way that is thoroughly practical. A task that is immediately apparent is the need to deal more effectively with published engineering information and to evaluate the data that are published. Beyond that, there are the more advanced forms of information handling which can be foreseen.

These matters will be analyzed and illustrated by the distinguished speakers who have been brought together on our program, and may I express my very great personal appreciation for their participation.

Just a final word, before I introduce your chairman.

I have on my desk a little card showing a man sitting by two baskets knife in hand — and he has obviously been peeling a lot of potatoes. The caption reads: The best potato peeler is the one who peels one potato at a time."

And so it seems to me that we are now engaged in peeling potatoes. We'll take one at a time and, in that way, we'll peel the most.

[1] Chairman of the Board, The Detroit Edison Co. and President EJC.

KEYNOTE ADDRESS

Framework for an Engineering Information System

BY BURTON W. ADKINSON[1]

The engineering community once again is taking the initiative in organizing a national system. I say "again" in reference to the program started many years ago when the Engineering Index and the Engineering Societies Library were set up and a comprehensive publication scheme was adopted. The lessons learned from that endeavor, plus the fact that effective transfer of information is a basic engineering problem, put engineers in a unique and favorable position for success in the effort that is the theme of this symposium — a coordinated engineering information system. It is my intention to suggest several factors that may affect the outcome of these aspirations.

Role of Comprehensiveness

The first factor is *comprehensiveness*. By this I mean information which is germane to engineering, although not universal in scope, and that extends over a broad range of sources, kinds, and users.

An umbrella program such as yours must cope with an increasing number of sources of information. Most obvious is growth of the membership, made up of individuals and organizations. A complicating aspect is the interdisciplinary nature of most of today's engineering problems, involving mixtures of social, psychological, and economic elements. They require inputs from the farthest reaches of physics, chemistry, or biology. And they may require solutions applicable inside, on, or outside the earth and its atmosphere. The explosive growth of engineering effort in other countries further complicates the source problem, with the language barriers that must be hurdled as a result. To cover such a variety of information sources, obviously your system must provide for a large number of connections with other systems, as well as extensive switching mechanisms to permit users access to whatever mixture of subjects they need at any given time.

With respect to *kinds* of information, I need only point out that the conventional view of information as words found in documents is not broad enough. Engineers are well aware of this because of extensive use of handbooks of data, blueprints, charts, diagrams, and the like. But now we have learned that an enormous part of significant information transfer doesn't even involve paper. Word of mouth, aided or not by telephones or public address systems, accounts for much of it. It is imperative for comprehensive information-systems design to utilize the spoken transfer of information and provide oral communication links as well as document distribution mechanisms.

There is one more vital facet of *comprehensiveness* known as user coverage. It seems that much of the recent information frenzy has been distorted by a tunnel-vision effect. Concentration on one band in the user spectrum has left vitally important spectral bands neglected. Many of us have worried so about the professionals that we have forgotten the practitioner and the administrator.

The information needs of the man at the bench and the manager are as important as those of the engineer-at-large interested in keeping himself up to date, or in familiarizing himself with the background to a new problem. And these needs will not necessarily be satisfied by the same means, such as the engineering journal, that provide for the professional while he is acting as such.

Every problem that must be faced in raising the framework for an engineering information system presents a continuum of source, kind, and user; a truly effective system should be comprehensive and cover each spectrum thoroughly. The natural tendency to select only a few facets and ignore the rest when faced with a multifaceted problem has led many information-system proposers down dead ends. Their systems have served such a limited set of users, or such a limited part of the needs of large sets of users, as to leave them without supporting customers. Engineers of all people should be able to avoid these pitfalls.

We must not underestimate our ignorance in this area. It will take brains, as well as organizational brawn, to devise a system comprehensive enough to do the job.

Role of Response

The second major factor that the information program must take into account is *responsiveness*. One reason that engineers are going back to the drawing board to recast the information transfer system is that the original designers didn't build mechanisms to allow for change. Arranging for the collection and transmission of control data necessary to keep information transfer circuits responsive is a problem peculiar to engineering. Responsiveness of the sort I have in mind has two elements: One, the *kind* of information transferred by the system, and its *processing*, yielding a mixture of outputs at any given time; two, the change of both *kind* and *process* with passage of *time*.

[1]Head, Office of Science Information Service National Science Foundation.

I doubt that anyone has in hand a clear enough picture of engineers' information needs to design a perfect system today. In fact, since the operation of the system will itself modify the pattern of need, such a picture is probably basically unobtainable. A successive-approximation, or continuously evolving, approach is, therefore, the only one open to you.

Every User Plays a Part

Stressing the need for control-data loops, what is often overlooked is the fact that the most important source of control data in an information transfer system is not within the system itself. It is in the individuals that the system serves. If the system is going to reach any state of real value, then, it must not only be user-oriented; but also the users must be system-oriented. Unless the engineers who use it feed in control data, from the first approximation on through every successive modification, it cannot achieve success. Every user must make himself heard in the design and use of the system.

The second element of responsiveness rests with time. As time passes, the system must respond to technological advances that promise improvement in the information transfer process. It must also respond to changes in technological emphasis that result in basic changes in patterns of user need.

Designers and operators are responsible for response to technological advance. Users cannot very well feed in information on the value to them of new devices or information-handling techniques whose products they have not yet received.

Responsibility for calling attention to changes in need, however, is definitely shared by the users, whether they be individual engineers or intermediaries such as libraries and abstracting-indexing services, or data centers.

One more pitfall seems to apply to information systems more than others. The very flexibility and responsiveness that are required imply continuous change, and change leaves disused materials behind. These can clutter the system to a standstill. Provision must be made for getting rid of deadwood that is left behind by changing times.

This question of responsiveness is no academic issue. Today, more than ever before, systems stand or fall by the only criterion we have, namely — user reaction, measured by real use. If your users don't benefit from its operation directly, or indirectly through libraries, information centers, and the like, they won't use it. If they don't use it, they won't pay for its services. If they won't pay, steadily increasing difficulty will arise in getting Federal funds to make up the deficit. However, the whole question of financial underpinning, with its broad implications is one issue that we must come to grips with.

Comprehensiveness and responsiveness, as I have described them, are the two most important foundation blocks upon which to build an information system. Engineers as a group are ideally suited to design a system that will effectively incorporate these principles.

Planning for National Information Networks

BY WILLIAM T. KNOX[1]

It is my great pleasure to share some thoughts about the role and the activities of the Federal Government and the nongovernmental sector in the development of information systems in science and technology.

In a way I feel like a missionary, but not in the sense of trying to propagate the faith that some of us have that progress in science and technology can result from better information-handling systems. Rather, it is to advocate a partnership of the government and the private sector in fashioning the tools — the information systems — that will meet our present and future needs. I stress the word *partnership* because I sincerely believe that while Federal information system improvement is a vital ingredient, the larger need is *national* information system improvement. It is in this positive sense, then, that I describe myself as a missionary, seeking to convert your curiosity into interest, and your interest into action. Without the full participation of the engineering profession in the planning of national systems and in their execution, progress will continue to be slower than it need be. In both professional and the public interest, each member of the profession has a role to play in the development of national systems for scientific and technical information.

Information systems might be described as that large, somewhat amorphous complex under the general heading of scientific and technical information activities. "Systems" is the proper concept, because it is through a series of related systematic functions that information is transferred in order to promote the progress of science and technology.

There has been too much emphasis on scientific and technical information systems problems per se; they should be related to the cause they serve, the reason for their existence — the progress of science and technology.

President Kennedy focused attention on the real issue when he said, "One of the major opportunities for enhancing the effectiveness of our national scientific and technical effort, and the efficiency of Government management of research and development lies in the improvement of our ability to communicate information about current research efforts and the results of past efforts. Strong science and technology is a national necessity and adequate communication is a prerequisite for strong science and technology."

Emerging from this basic declaration of purpose, those Federal Government organizations concerned with over-all plans and policies for research and development have increased their efforts in the past in specific programs to improve scientific information systems.

The Federal Government's technical information activities are brought to a focus in one of the committees of the Federal Council for Science and Technology, namely the Committee on Scientific and Technical Information of which I am chairman. This Committee is often called by the acronym, COSATI, by which it is known throughout the nation in information circles.

The Federal Council for Science and Technology is the over-all advisory and coordinating mechanism for scientific and technical activities within the Executive Branch of the Federal Government. I also assist Dr. Donald F. Hornig, the President's Science Adviser and Director of the Office of Science and Technology (OST). The OST advises and assists the President in over-all coordination, planning, and evaluation of Federal programs in science and technology. COSATI provides the principal mechanism for obtaining individual agency views and reaching agency consensus on desirable activities and programs of the Federal Government with respect to information systems for science and technology. The Office of Science and Technology provides an executive device for implementing the recommendations of COSATI.

COSATI — Procedures, Goals

Here is an outline of the scope of COSATI's concerns relating broadly to all the scientific and engineering disciplines and to all of technology. The breadth of problems being studied by COSATI can be understood better by considering the work areas of its panels.

The Operational Techniques and Systems Panel is concerned with acquisition, accession, abstracting, indexing, announcement, distribution, terminology control, equipment compatibility and convertibility, wholesale and retail resources, specialized information centers, libraries, and depositories. This is the "work horse" panel, charged with improving the quality of performance and coordination of current and near future Federal agency programs.

The Information Sciences Technology Panel is responsible for making recommendations for the orderly development of information sciences technology by avoiding unnecessary duplication of agency R&D efforts,

[1]Staff Member, Office of Science and Technology, Executive Office of the President.

identifying gaps in agency R&D programs and orderly transition from current to improved systems.

The Education and Training Panel is concerned with improving education and training of information specialists, and means for increasing their supply. It also recommends programs to help educate scientists and engineers and managers in the use of information resources and systems.

The International Information Activities Panel — This country needs information produced by scientists and engineers in other countries. As plans for computerized information systems serving an international community are developed, it is important to have a panel to help coordinate Federal agency activities to set standards for systems; to recommend international exchange policy and procedure, and to improve the many translation programs carried on in and out of government.

Other panels under consideration are as follows:

Information Generation — This will include such areas as reporting techniques, input quality control, technical writing, meetings and symposia, and security, proprietary, and copyright matters. The Information Generation panel thus is concerned with the beginning of the information cycle.

Information Users — As the name implies, the Information Users panel will be concerned with users and their needs for information and data; also with steps to be taken to let users know the information resources that exist, and how to get to them.

External Relationships — The government is a big factor, but not the only factor in the information business. Industry, the universities, trade associations, and technical and professional societies have a considerable stake in science and technology. Pending the formation of a panel on External Relationships, contacts between these groups and the government are taking place. Sometimes only one nongovernment group or organization is involved; sometimes many groups or organizations meet with representatives of COSATI, the National Science Foundation, and the Office of Science and Technology.

COSATI's concerns thus embrace the systems used to actually transfer documents and information from one user to another, but also embrace the initial publication processes and the producer of information, the user groups with their varying information needs, and the education and training of information systems operators and the producer-user groups in the use of modern information systems.

The size of the Federal government's program is not easy to determine. This is basically because it is difficult to make a distinction between some information activities and the research or engineering activities of which they are an integral and essential part. To all scientists and engineers, information transfer is an inseparable part of their science and engineering. But recognizing the difficulties in separating information services from other aspects of research and development, COSATI has developed some rough budget estimates for information programs of Executive Branch agencies for Fiscal Year 1966, as shown in Table I.

Table I. — Budget Estimates for Government Sci-Tech Information Activities (in millions of dollars[1])

Publication and Distribution	130
Bibliography and Reference Service	80
Information Sciences and Systems, R&D	60
Symposia and Technical Meetings	40
Information Centers	20
Management and Training	20
Media-Audio and Visual	10
Budget Issues	10
Translations	5
Support Publications	5
TOTAL — ESTIMATED	380

[1]Numbers rounded. Estimated obligations, not expenditures.

A number of actions have been taken by Federal agencies to improve information systems as a result of COSATI studies and recommendations. Some of these are:

- A uniform policy to guide Federal agencies on financial help to nonprofit, nongovernment scientific publications. This is the so-called "page charge" policy, whereby Federal agencies pay certain costs of publication, if requested by the publishers.
- Standards for microforms of technical reports called "microfiche." We expect that this new standard will create a new, large market, and thus lower unit costs.
- A uniform method for identifying Federal reports, described as "descriptive cataloging," which will be a particular help to those people who have to store and retrieve reports.
- Finally, a subject category list which is to be used throughout the Federal Government for the announcement of reports and which will make it easier for Federal report users to locate information.

While these COSATI actions do not have the glamor of a space-walk, they are significant actions in bringing about better coordination of Federal and non-Federal information activities. We will have to follow their implementation, modify and correct them when necessary, and continue working hard on other standards and policies.

In addition to the above-mentioned actions, whereby individual agencies and nongovernment organizations have made their own information systems more effective and more efficient as components of the total national network, COSATI has been the mechanism by which, or with whose endorsement, several new organizations have been created to carry out special functions of the national network. These new central organizations are:

- The Clearinghouse for Federal Scientific and Technical Information
- The Science Information Exchange
- The National Referral Center for Science and Technology
- The National Standard Reference Data System

About nine months ago, following several suggestions from committees of the Congress that the Executive Branch exercise stronger, more aggressive leadership in this area, an interdepartmental COSATI task group began to develop the conceptual framework of a plan for improvement of the over-all complex of scientific and technical information activities in the United States.

To develop a realistic conceptual framework, it was necessary to consider as well, the activities outside the Federal establishment since the non-Federal and Federal activities are mutually dependent on each other, and large sums of Federal funds go directly or indirectly in support of these activities. Early in the delibera-

tions of the COSATI task group, the importance of continuing dialogues with representatives of the various nongovernment components of the complex of information systems was recognized.

We have already participated in a number of special meetings held to present the task group's preliminary thinking regarding a *concept* goal for the information systems in the United States. These meetings have included top-level representatives of scientific and engineering professional societies, industrial and trade associations, the technical and business press, and library groups.

Although there are many other areas of interest, the task group has focused its efforts so far on formalized communication mechanisms, primarily document-handling mechanisms. In part, this emphasis is due to the relatively well-organized subsystem of document-handling activities, compared to the less structured nondocument systems for information transfer. The task group has been assisted by a study team from the System Development Corporation, and the first report was to have been made publicly available about November 15, 1965.

What have we developed so far? First, we have concluded that the far-flung, widespread nature of the information system can be roughly conceived as partially analogous to the telephone network, which is a mechanism for connecting people who want to know or to talk with other people who either have the desired information or are willing to listen. The telephone network is a mechanism completely at the service of its users, and it demands only an elementary knowledge to be able to use it. The telephone operates on a real-time basis, however, and this is a big difference from information systems, which in part transfer knowledge acquired some years ago to today's users.

Document-Oriented, and Information-Oriented Systems

To recognize this difference in user need, and to differentiate between functions and types of people involved, we have, in our preliminary thinking, divided the body of the national network of information systems into two parts. First, a complex of library systems (document-oriented, such as traditional libraries), and second, a complex of information evaluation and retrieval systems (information-oriented).

A basic proposition has been put forth by the task group for further consideration to the effect that the Federal government shall have the responsibility for ensuring the accessibility within the United States of a copy of all significant worldwide literature in science and technology. This does not mean Federal operation of the document-handling system, but only Federal responsibility for ensuring an effective system.

There seem to be necessary several libraries at the national level, handling documents in such fields as medicine, agriculture, engineering, earth sciences, physical sciences, and behavioral sciences. Each of these libraries would be concerned with acquiring all the pertinent literature in its field, cataloging or indexing it, announcing the availability of the literature, and providing copies if requested. These would be structured, operated, and administered to meet some standard system requirements or specifications, but would not necessarily be operated by the government. Each national library would be the responsibility of a Federal agency with primary mission responsibilities in its field of interest, such as the National Library of Medicine with responds to the mission of the Department of Health, Education and Welfare. Coordination and compatibility among the libraries would be a primary goal from the beginning, and a question for early decision is the mechanism for bringing about this coordination.

Because of the size of our population, and the diversity of demands made on libraries for documents, ranging from help for the teen-age student, the needs of the lay adult, the needs of small and large business and the professions, the rest of the library network will be essentially retailers of documents. Other library systems (Federal, college and university, public, specialized, industry, institutes, and schools) would, as now, look to the national libraries for loan of documents, and catalogs, as may be appropriate, and would, in turn, provide some of the input to those libraries. But their main role would be to serve those users who will be satisfied with documents.

The other part of the system — the complex of evaluation and retrieval systems — would consist of those activities of Government agencies, universities, industries, and societies (professional, scientific, and trade) that are concerned with providing information, as opposed to documents, to specific audiences directly concerned with science and technology. Elements of this system would be expected to:

1. Provide secondary current awareness, such as abstracts bulletins;
2. Analyze and evaluate information; not only the information contained in documents but also that information just developed and still unpublished;
3. Facilitate searching of the literature through deep indexing and other means; and
4. Retrieve specific information on request, that is, answer on-the-spot questions.

These information-oriented activities are normally more closely identified with the research and development programs and the scientific disciplines than are the document-oriented activities centered on libraries. They require scientific and technical orientation and competence of the participating personnel. An improved mechanism is needed for bringing about the desired coordination of effort, and here, especially, the government needs the advice, assistance, and active involvement of nongovernmental groups. The task group will begin active study of this part of the national network very soon.

We look forward to continued progress in interagency coordination, and the increasingly productive cooperation with the nongovernmental community.

Accord Between Federal Government and Technical Community

The advent of national computer-based information systems will raise new issues along with some difficult problems. Because of the Federal Government's deep involvement in the national effort in science and technology, and its close relation to, and financial support of, the extensive nongovernmental activities in so much of the information network, the Congress will ultimately have to decide what parts of the evolving modern information network and to what degree these parts are appropriately Federal Government responsibilities. As the report[2] of the President's Advisory Committee said,

> Government involvement in scientific communication is going to grow, just as Government involvement in science and technology is growing. We must always seek to ensure on behalf of both the Federal Government and the technical community, that the Federal information system remains adequate but does not overwhelm the existing non-Government systems, and that our Government and non-Government systems continue to develop into an effectively interwoven instrument that is always responsive to the changing needs of our science and technology.

Other difficult problems are the sources and mechanisms of financial support for the information network. Federal agency information services are usually subsidized by the general tax-paying public for the benefit of the users of the service. This is sometimes justified on the grounds of eliminating the costs of billing and collection of charges for many small items; sometimes on the grounds that more use is encouraged if the services are provided free; sometimes because it is judged to be for the general welfare. It is common experience that people associate value with cost and, in most cases, they are willing to pay for something they really need. In the absence of a cost-controlling mechanism, an information service, like other services, is likely to become unwieldy and cumbersome and unresponsive to user needs. Such a situation could lead to overemphasis on the production or processing side, and to underemphasis on the true needs of the user, which is the marketing side. A mechanism by which the users of an information service are made to pay some part of the costs for the service is a valuable control device. It also acts as a spur to the information service managers.

Another serious problem is the lack of adequate skilled manpower for the modernized information network, and the dearth of adequate information facilities on our college and university campuses, where the future users of the system are being trained.

But the problem demanding greatest attention at the present time is that of creating a permanent mechanism for ensuring the effective, efficient management of the vast and almost incredibly complicated series of functions which together make up the national information network.

Let me mention a few possibilities for a central management mechanism. These are:

- A COMSAT-like corporation deeply involved in the actual operation of the information network, with both governmental and private interests.
- A new Federal agency managing all agency sci-tech functions, much as the General Services Administration handles other services.
- A new Federal agency restricted to top-level planning and evaluation, with existing agencies continuing to manage their internal information systems.
- The assignment of top-level planning and evaluation functions to an existing Federal agency; or a continuation of the presented multifaceted management.

These possibilities, and others, are now being examined closely by the COSATI task group and the System Development Corporation.

The foregoing is a word-picture of what COSATI does and how the Task Group on National Systems for Scientific and Technical Information is proceeding. I have told you about some of the problems we face and about trends we must consider and I have outlined some of the actions already undertaken and being planned by the government. I have highlighted my concern that organizations such as Engineers Joint Council must participate in the program of developing a national system and that the stakes are high for us as a nation, as well as individually.

[2] A. M. Weinberg, et al., **Science, Government, and Information: The Responsibilities of the Technical Community and the Government in the Transfer of Information**, 10 January, 1963.

Concepts of a National Engineering Information System

BY WILLIAM J. HARRIS, JR.[1]

Engineers spend a significant fraction of each working day acquiring information. Each engineer is aided in his information-gathering function by local and national resources, but at the present time these resources in the field of engineering are fragmented and by no means constitute an organized national engineering information system (NEIS).[2] It is the purpose of this conference to discuss various aspects of such a system. My responsibility is to review its general relationship to the engineering profession.

Mr. Knox has given an account of the activities of the Federal Government in many fields of information stating that national information systems in various fields of professional interest are being established or will be established. The Government recognizes a responsibility to ensure the development of a more effective national engineering system, and Mr. Knox says the Government hopes that some entity in the profession will step forward and organize such a system and be prepared to operate it. Such systems are now being organized in the fields of chemistry, medicine, agriculture, and in the sciences. The interest of the Government is that an engineering information system be created and operated in the near future, whether by someone in the engineering profession or by an entity of the Government itself. Some action on NEIS will undoubtedly be expected in two years.

In analyzing this broad opportunity for the profession, it is well to keep in mind that diverse information services are being provided by the Government, the universities, and the engineering societies. Some people in industry and in the universities are "haves" with respect to information, and some are "have nots." The "haves" are those who, through their professional or institutional relationships, have ready access to organized, unclassified (unlimited) information, foreign information, classified information, and proprietary information; the "have nots" fail in one respect or another to have access to a part of the available information.

The Need for NEIS

Those advocating NEIS hope that it will decrease the number of people who are in the "have not" category although it cannot deal with all aspects of classified or proprietary information. However, the first question that we must address as members of the engineering profession is whether or not in our judgment there is a need for NEIS. From what I have seen, Government leaders believe that such a system must be created because the Government pays for about 75 per cent of all the research, development, test, and engineering programs conducted in this country and they believe it to be in the national interest to assure ready access to the resulting information. It recognizes that the probability of the United States maintaining technical superiority will be enhanced if the scientists and engineers of the country have ready access to the results of research and development.

Beyond this general argument, I should like to review the responses of selected, high-technology industries to their needs for information.

High-Technology Industry Uses Information

Industries to which the Government provides major research and development support receive also literally dozens of special aids to insure the dissemination of all relevant technical findings. These centers or services exist in the Department of Defense, National Aeronautics and Space Administration, Atomic Energy Commission and the Departments of Agriculture; Health, Education and Welfare; and Commerce. The Clearinghouse for Federal Scientific and Technical Information was created to assure that unclassified reports on projects funded by major government agencies are made rapidly available, on a fee basis, to a defense industry but also to nondefense industry. I will comment on the relevance of the Clearinghouse to nondefense industry.

The Government has created major information systems to prepare state-of-the-art reports and interpretive analyses, particularly for defense users. These information and evaluation centers have an input from the classified literature, from the proprietary literature, to at least a modest degree, as well as from domestic and foreign unclassified literature. Thus, through the support of document and evaluation centers, the Government has taken steps to insure that an effective information dissemination system exists to serve defense industry.

With respect to nondefense industry, the chemical industry does more company-funded research than any other in the private sector. This industry has been applying foreign science as well as domestic science for many decades, and is a major force in international business competition. Because of its urgent need for timely reports, it has been a leader in creating a sound information system through the journals and abstracting services of the American Chemical Society. In this nondefense industry, oriented toward the effective utilization

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[2] These initials will be used in this report for editorial convenience. They by no means constitute a recommendation as to the final name of this activity.

of science, it is evident that major attention has been given to the establishment of an information service as a necessary professional service; and, parenthetically, it is worth noting that the leadership in information activities in the Engineers Joint Council, in the Committee on Scientific and Technical Information of the Federal Council for Science and Technology, and in the Department of Defense has been exercised by individuals drawn from the chemical industry.

Other domestic industries have been substantially less concerned with the foreign market and with foreign science than the chemical industry. But, as the rate of technical advance increases, it is likely that a demand for a comprehensive service will grow in many industries; signs of this are already in evidence in metallurgy and materials. Much attention is being directed toward improved information dissemination in academic and governmental institutions as their need for information is great. NEIS would have to be designed to serve these groups as well as industry.

The rapid growth of technology demands that NEIS be established to provide a comprehensive resource of information and data. Many parts of this system already exist, but the services are fragmentary and incomplete. We can assume that the Federal Government will develop and operate such a system in the relatively near future unless some entity in the engineering profession steps up and demonstrates its capability to serve as the operator. With increasing competence based on its experience, the Federal Government could easily expand many information programs to provide a full range of desired services.

From the standpoint of the profession and the private sector of our economy, Federal operation would indicate that we had failed to assume our professional responsibilities. Accordingly, I think we should take the necessary action to put ourselves in a position where we could operate such a system. In taking this action, we should direct much effort toward arranging for a significant degree of private financial support for this system, based, at least in part, on charges for services rendered.

Operational Concepts

There appear to be two basic concepts of operation — one, a monolithic institution, a self-contained facility; two, an in-house capability, giving major attention to strengthening other resources and designing switching systems according to their compatibility with the in-house capability. This second concept would lead to a network of operations functioning as a comprehensive system. It would be easier to set up a monolithic operation because direct supervision is generally more efficient than the coordinated institution or network. However, too many existing operations and interested parties in the field would oppose a monolithic system; inevitably, their role must be recognized. For a network operation to function properly, standards of indexing and information processing must be established by agreement with all of the institutions involved in order that the switching can occur with minimum delay. Some organizations have been able to do this. The NEIS can be expected to have in-house competence but also much interaction with other centers.

Plans for Joint Action

A new legal entity inevitably will have to be created because even though interdependent, the NEIS must be developed and operated by a single, appropriate institution, not by a committee or a multiassociation board. From my experience, there is no institution in the profession now that has such an over-all responsibility. Therefore, such an entity would probably serve as operator and as a contact focal point for the engineering profession in dealings with the Federal Government regarding the information system. This entity will most likely be established as the result of consultations between the several organizations that operate parts of this program. Those with a major interest are: the United Engineering Trustees, because of its operation of the Engineering Societies Library; Engineering Index, Inc., because of its operation of abstracting and indexing services; and Engineers Joint Council because of its coordinating role in the engineering profession, and its leadership for the past three years in the field of information processing. We owe much to those leaders of three years ago who called upon the profession to take action to cope with some of its pressing information problems.

Recently, the presidents of these three organizations met as a planning committee, looking toward steps that should be taken in the continuing study and possible development of a national engineering information system. The profession must be prepared to support the decisions of these people if timely progress is to be made toward the establishment of such a system. Each of these institutions may have to transfer parts of its operation to the new entity.

Functions of NEIS

Any information system which is comprehensive in nature probably should include a range of functions such as the following:

- An archival function is necessary implying a resource which can store and retrieve books and major documents.
- A journal processing function should provide for indexing, abstracting, and ready retrieval.
- A redissemination function must be included both of primary documents and of secondary documents (those containing appropriate abstracts which are more informative than indicative).
- A service that assures timely state-of-the-art reports is necessary to provide a broad background for people not now in a specific field and to assure current awareness by those in the field who are narrowly specialized.
- Specialized assistance in response to definitive questions from individuals will have to be made available at some point in the development of NEIS.
- Research and development on information dissemination problems, including storage, retrieval, and analysis will certainly be essential functions of the new organization. Many groups and companies are already engaged in research and development or marketing equipment and developing new systems. The new engineering entity must be in position to consider these developments in an informal manner and make critical evaluations.

- User studies are essential to an effective information activity, for without a continuing analysis of the changing needs of users, it would not be feasible for the management of NEIS to allocate resources in the optimum fashion.

Assessment of System Requirements

This listing of services by providing a basis for appraising the capability of the engineering profession in each of these fields gives opportunity for assessment of how far we have to go in the development of each of the pieces of an information system. I should like to present this part of the problem in the form of a series of questions and what seem to me to be appropriate answers.

QUESTION: Do we have an archival function in the profession adequate to the demands that may be made on it?

ANSWER: The Engineering Societies Library operated by the United Engineering Trustees, from my observations, is not adequate to serve the full needs of an archival function. Support for it would have to be increased by a factor of three or four if it were to provide an adequate in-house service and connect other libraries which could be drawn into a national network and, with other resources, such as the Clearinghouse for Federal Scientific & Technical Information and the Defense Documentation Center. It will be necessary to have a special staff service, that is nonexistent at present, at the Engineering Societies Library which would work toward effective relationships with other libraries and the development and application of standards so as to enhance switching.

QUESTION: Do we have an adequate indexing and abstracting resource? Is the current Engineering Index service adequate to our needs?

ANSWER: The Engineering Index has never been supported sufficiently to achieve the comprehensive services within the field of engineering that will be required to meet the demands of NEIS. Accordingly, we must find a way to create support for an appropriate indexing service and assure compatibility between that service and equivalent services in other fields, for instance, Chemical Abstracts Service.

The fact that Chemical Abstracts Service has a staff of about 710 while Engineering Index has a staff of 75, with 34 of those individuals involved in indexing and abstracting, is indicative of the present deficiency in coverage by the Engineering Index. The Chemical Abstracts Service need for abstracting is taken care of by over three thousand members of the American Chemical Society. This would imply that the Engineering Index should be increased by a factor of about 10 to achieve adequacy of coverage. Furthermore, the Engineering Index staff must coordinate with other facilities engaged in abstracting such as the Clearinghouse, the American Society for Metals, and, of course, with Chemical Abstracts Service, and other national information services.

QUESTION: Do we have a system in the profession for making available data resources, guidance to specifications, and other design information?

ANSWER: A dozen or more societies prepare individual handbooks that cover many but not necessarily all fields of engineering. There is no mechanism for insuring adequate coordination of the handbook operations of the societies. Under the aegis of the Engineering Foundation, there is being created the Metal Properties Council which intends to establish a data center to bring together property and other relevant data on metals. The American Society for Testing and Materials is an important specification resource but more coordination is needed particularly with Government and industrial specifications. The American Standards Association does serve a vital role in this field. A new standards organization, still under consideration, will provide more effective coordination of Government and industrial activities on standards. This function may fully serve the needs of NEIS. Because of the relevance of data to engineering design, the new system will have to develop an appropriate approach for handling engineering data and handbooks. It will be essential to coordinate this data system with the work of the National Bureau of Standards and its National Standard Reference Data Program. Such an extensive adjustment will demand that the new engineering information system have a highly competent professional staff.

QUESTION: Is there a system to make accessible comprehensive state-of-the-art reports in new fields? It should serve to bring professionals in the field up to date from time to time and provide an introduction to its present status for professionals not in the field.

ANSWER: Government-sponsored information and analysis centers provide state-of-the-art reports, but these centers do not cover all fields of engineering. Each society issues review articles drawn from interpretive symposia but these are not nationally coordinated to assure comprehensive and continuing services. State-of-the-art reports are expensive because they require large blocks of time of highly competent individuals, and while these reports may not be a part of NEIS in the beginning, ultimately their place in that system will have to be developed.

QUESTION: Is there a research and development program with respect to the field of information and data storage, retrieval, and dissemination in the profession?

ANSWER: There is no continuing research function provided in this field, although some studies leading to improved systems for handling information have been made by the profession and by a few of the societies. Considering the complexity of NEIS, it is essential that any new entity created to operate it be able to conduct research and employ individuals who are in position to evaluate the results of research by others. Again, the cost of creating this new service cannot fully be projected at the present time but the function of information research and evaluation of research results is important to identify with the new center.

QUESTION: Does the engineering profession understand the needs of the information users?

ANSWER: The profession, made up of generators and consumers of data and information, in general, has not studied the information needs of its members. Those engineering groups such as the American Society for Metals, with information services, conduct some studies for users in order to test the market for their services. However, there is no continuing assessment of user interests. The DoD is now making important studies on this topic. Any engineering information system would have to concern itself with the users so that the services provided by the center could be kept in harmony with the needs of people in the profession, and of the institutions that serve these people. Again, this service is not now provided but must become a part of NEIS.

QUESTION: Are the basic journals produced in the United States in the field of engineering coordinated and comprehensive for effective service to the profession, and are the resources of foreign literature being effectively handled at the present time?

ANSWER: With respect to foreign literature the Clearinghouse for Federal Scientific and Technical Information provides a valuable resource, and the Engineering Societies Library would be expected to be a subscriber to all relevant foreign journals as well as domestic journals.

An historic function of the societies is to publish material of concern to the professionals in that society, but a reassessment of current users and a change in the price structure of information processing may substantially alter the relationship of professional societies to distribution channels of technical information. The engineering profession cannot compare itself to the American Institute of Physics which assures physicists an integrated series of journals. Further, the profession is faced by an increasing encroachment of trade publications which publish articles of importance to the profession in journals not controlled by the societies. Changing technology of publication and distribution may alter the relationship of a society to its journals.

Ultimately NEIS will have to be in a position to understand the trends in journal publications which is a sensitive issue of great concern to each of the professional societies. NEIS may have to serve in an important capacity by studying journals or even by making arrangements to assure that papers are effectively distributed to members of the profession.

While it may not be feasible to include coordination of information resources within the original functions assumed by NEIS, there should be a central point of reference for the continuing review of this problem. Steps must also be taken to assure each of the societies that no one has any desire to compete with it, in the profession at least, in its appropriate professional concern with the material being presented for publication or distribution by people who identify with the profession.

We Must Act Now

These remarks indicate that there are not adequate information services, institutions, or activities in any single area of the profession. If, in response to the interest of COSATI, we are going to create NEIS and take the first steps toward its operation within the next two years, we must urge the presidents of our three coordinating groups United Engineering Trustees, Engineering Index, and Engineers Joint Council to speedily develop a legal entity that can begin to plan the expansion and effective coordination of the facilities in the profession relevant to a national service, looking toward a comprehensive and integrated service.

There are three major obstacles to success that stand in the way of NEIS:

1. Despite the existence of many information services in the engineering profession, there is no organization that sufficiently commands the respect in the profession to insure coordination of these services; nor has there been any indication that individual units in the profession will willingly and enthusiastically transfer to a new entity the responsibility for managing a comprehensive service. Unless these conditions are recognized and this problem met, NEIS, managed by the engineering profession, will not come into being. In three years, EJC has been able to win support from no more than one-half of the societies for source indexing and use of the EJC indexing system.
2. No entity exists in the profession that has sufficient financial resources to hire a staff to handle the demanding tasks of preparing a detailed plan of action and proposals to elicit the necessary financial support from industry and Government. The preparation of such a proposal is a demanding task. I have been advised that the proposal submitted to National Science Foundation by the American Chemical Society for the development of an integrated, computer-based chemical information system took more than 24 man-months of effort despite the 60 years of experience of Chemical Abstracts Service. The studies that the EJC Information Systems Committee have made, to date have involved a great many dedicated, highly competent people. However, this effort represents no more than a small percentage of the total effort necessary to create the proposal that will be accepted by the Government as the basis for support of a national engineering information center.
3. We have not yet won agreement in the profession, or in the associated industries, that NEIS is essential and must be given enthusiastic support by major financial contributions for the expenditures required to operate such a system. As an example of the problems that NEIS may face, we should recognize that nearly a decade of subsidy from society income and governmental grants was necessary before the American Society for Metals information service was well enough developed for even a modest fraction of the costs to be recovered by charges to users. The NEIS will require the same degree of support from the profession, industry, and Government as it develops its capacity to provide services.

I believe that a national engineering information system will emerge and begin to function in the next two to three years, but it is not at all certain that the NEIS will be operated by an entity in the engineering profession. If the profession wishes to manage the NEIS, the steps that it must take are clear. It must create a legal entity that can study, plan, and if all goes well, operate such a system. Concurrently, it must give that legal entity undiluted support. We cannot ever hope to achieve the NEIS without integrating the plethora of information services that now exists.

A Look Ahead

BY MORRIS RUBINOFF[1]

Libraries are as old as the written word. And librarians have been faced, since ancient times, with the problems of acquiring, cataloging, indexing, storing, and retrieving documents for the information that they contained. The problems may be old but the solutions are new, as new concepts and new technology are put to work in support of the library operation.

The engineering societies (and the practicing engineer) are closely connected to the library through their publication activities. Each engineering society serves the professional community by both oral and written dissemination of information within its area of specialization. But it also serves as the compiler of a permanent record of the latest developments in its field and monitors the quality of that record by careful review of manuscripts before accepting them for publication. The engineering society is thus an important contributor to our rapidly increasing library resources.

The human brain is not unlike a library resource; it acquires facts and figures and formulas from selected fields of interest, catalogs and indexes them, files them away, and then retrieves them at will when occasion demands. But the human brain is blessed with a number of advanced library skills, exhibiting capabilities far beyond those of a simple passive memory device.

For example, the human brain has an ingenious classification and indexing system that permits it to browse through its information store, locate significant facts at incredible speed, arrange and rearrange its information store in a multitude of organizational structures, and thus to associate seemingly diverse concepts in a multitude of meaningful interconnections. Modern libraries have recognized this ability and have begun to imitate it through indexing of publications and search by concept coordination and similar techniques.

Because the brain is an extremely effective processor of logical expressions, it exhibits the ability to decide for itself what further information to retrieve while the search is in progress. The brain may make use of a logical feedback mechanism for this purpose, but the exact process is not yet known. Adaptive search procedures of this kind will eventually be developed so that mechanized information centers will automatically contribute to the logic of library search.

A particularly powerful quality of the human brain is its ability to infer meaning from words. This enables man to interpret the semantic content of documents, to correlate and associate their intellectual contents, and to compare those contents with existing knowledge. A strong beginning has been made in developing mechanical tools for manipulating written records through their automatically inferred meanings, but progress in this area has been slow.

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Improving Access to Information in Libraries

The classical technical library is largely limited to the passive memory function with textbooks and handbooks cataloged by conventional bibliographic elements such as author, title, and publisher, and indexed under a single main subject category. A certain amount of cross-indexing may be provided but the manual processes that are used for both cataloging and search, tend to inhibit the development of complex schemes. Professional society journals are acquired but their contents are not cataloged; the searcher is usually dependent upon annual indexes appearing in selected issues of the various journals, or upon specialized indexing services such as *Engineering Index,* to find the information he seeks.

Just after World War II a big step forward was taken with the introduction of index-term techniques. As applied here, an index term is a word or phrase which denotes a substantial topic, concept, or item discussed in a paper and having reference to the subject matter itself, rather than to the area of specialization of knowledge. Therefore, the term can be used for indexing papers in more than one engineering discipline (perhaps with mild differences in the meaning of the index term). The breadth of coverage of an index term is important because of the recent growth of technical knowledge accompanied by interspecialty and interdisciplinary cross-fertilization. Thus, index terms do more than provide deeper indexing; they also help the library to bridge conventional classifications of knowledge.

A document will normally be assigned five to ten index terms, and it can subsequently be retrieved through an inverted file in which a separate card is assigned to each index term and the code numbers for every document carrying that index term are entered on the card. Retrieval is accomplished by concept coordination, whereby several index terms are named by the searcher and only those documents are retrieved that appear on all the cards assigned to the given index terms. An important feature of concept coordination is that it is as effective for manual systems and small private collections as it is for mechanized systems of all types, including large computers with magnetic disk storage.

A limitation of the index term approach has been the high cost of indexing papers after publication. To reduce these costs for secondary services, EJC asks for indexing at the source, that is, for index terms to be provided by the author, reviewers, and the editorial staff at the time of publication. However, certain difficulties remain which stem from the redundancies and ambiguities of natural language; redundancies arise because two or more synonyms may describe the same concept; ambiguities arise because of homographs, where a single word has a multiplicity of meanings in different contexts and may mislead an information search. The current partial solution to the problem is the creation of a list of authorized index terms, called a thesaurus, with scope notes to resolve at least some of the ambiguities.

Source indexing is proving to be effective and popular and it is hoped that the practice will soon be adopted by all technical publications. This new tool will augment conventional cataloging and provide multiple subject indexing for all published papers. The *Thesaurus of Engineering Terms,* periodically updated, will serve the broad needs of the engineering profession and gradually become a vocabulary standard for library use.

But the proliferation of new engineering specialties (IEEE alone has over thirty specialized Groups, each with its own publication) will call for the compilation of specialized thesauri, called microthesauri. These will provide authorized lists of index terms encompassing the narrower confines of the various specialties and denoting subject matter at a more detailed level of engineering. At the same time, the interdependencies of these specialties will call for thesauri at intermediate levels, called metathesauri, with index terms selected from two or more microthesauri to interconnect their specialized vocabularies.

Standardization of vocabularies is a necessity for orderly management of libraries and for efficient and effective use of devices in mechanized systems. But a standardized vocabulary can limit the user in unaided search because it requires that he first scan the thesaurus to find a set of applicable index terms. A thesaurus or dictionary of terms containing synonyms, antonyms, generic or specific, and other relationships can facilitate the search for authorized index terms. Such thesauri are particularly effective in mechanized systems since they can be stored in the system itself with direct access from an on-line time-shared console, using a telephone connection when the console is at a remote point.

Real–Time Information Systems

We are looking to the development of a real-time system to accommodate a man-machine dialogue which provides the searcher with a probe for browsing in the mechanized library files. Clearly, such browsing is not a universal need. The user who seeks to study at his leisure is adequately served by batch mailing of documents in conventional form or in any one of the many microimage formats. But for the engineer with an immediate design, development, or production problem, the real-time console can be an almost priceless time-saving tool.

A significant aspect of real-time information retrieval is the introduction of languages more and more closely resembling natural English. A family of programs is being developed at System Development Corporation to make it possible for the searcher to question the computer and get responses in a language resembling English, and build additional programs, if needed, as he goes along. He can receive the responses and have them displayed in any format that seems best to him at the time, including tables, charts, graphs, and sketches. And he can adjust the text and the tables and even sketches and illustrations from the console keyboard or by light pen or sketch tablet.

The growth of information-handling technology will affect other aspects of our professional lives. Computer-controlled type composition of our technical literature will gradually be introduced. This implies that authors will eventually be asked to provide machine-readable copies of their papers, for example, on punched paper tape, at the same time as they submit their typewritten hard copy. Typewriters are now commercially available which generate such tapes as a simultaneous by-product of the typing process. A further implication is that manuscript editing and revision will be accomplished with the aid of computer processing.

For the engineering society and the technical library, computer-controlled type composition accommodates simultaneous capture of catalog information, index terms and abstracts, and therefore, rapid and economical machine compilation of abstract journals, annual indexes, and other search tools.

Computers will provide increasing service to libraries in other functions such as selective notification and dissemination of new documents to engineering society members, and practicing engineers who request the service. The selection is made on the basis of each engineer's fields of interest, as denoted by his own choice of index terms. As mechanized centers are established, and particularly with the eventual establishment of a United Engineering Information Network System there may be a gradual shift in the character of engineering society publications. More state-of-the-art reviews, tutorial papers, and summaries of new papers will appear. But the new papers themselves will be deposited in the mechanized system to be distributed only upon request.

What Is in the System

It should be noted that mechanized libraries are likely to contain more than conventional catalog entries, source indexing, and abstracts of papers. The system will also store inverted lists for mechanized search by concept coordination and other logical combinations of index terms. It will store handbook data such as the following:

- mathematical tables, for example, logarithms, trigonometric functions, probability distributions
- formulas, for example, the binomial expansion, definite

and indefinite integrals, Fourier and Laplace transforms
- facility for using formulas on-line to get specific values in real-time (note that such a facility eliminates the need for storing mathematical tables since the latter can be regenerated from formulas as needed)
- all important physical and chemical constants
- definitions of terms denoting concepts basic to the specific field and formulas interrelating primary variables
- technical and manufacturing standards; commercial and military specifications
- characteristics and design data of components and devices, including manufacturers' catalogs (thus providing a centrally available indexed file of up-to-the-minute data on available devices and equipment)
- tutorial text material on the physical and chemical properties of matter, and the central theorems and concepts of the field of specialization including figures[1], graphs[2], and illustrations[3] where appropriate.

The mechanized center will also contain its own manual of instructions, so that an on-line searcher will have access to a built-in "librarian" to help him in his search.

The Library of Tomorrow

To conclude with a summary picture of a community or company library of tomorrow, picture a National Information System with the United Engineering Information Network System as a component part; imagine a multitude of such libraries connected to the Network through consoles and data communication links. Books and articles in heavy demand are still on the library shelves. Manual tools for search and retrieval by concept coordination, such as optical coincidence cards, are at the disposal of the searcher who knows fairly well what he wants. And in at least one small study room is a console which provides direct on-line access to the mechanized files of the centers in the network for searches beyond the contents of the library, for recent publications and unpublished reports in the primary field of interest, and for general search of a number of mechanized files for materials in different but related fields of interest.

Picture the impact of such an information network on our educational world. Here is an example at the high-school level:

The year is 1975. In a small town in Pennsylvania, a class in Geography is under way. Resting on one side of the teacher's desk is a small keyboard console connected by a cable to a video display unit mounted on casters at the front of the classroom.

The teacher announces that today's discussion will be on the geography of Pennsylvania, and after she types out a message on the console keyboard, an outline map of the state immediately appears on the display screen. Another message, requiring access to an information file in a distant city, and certain vital statistics are displayed:

- area: 45,033 square miles
- 1970 population: 13,220,695
- capital: Harrisburg
- motto: "Virtue, Liberty, and Independence"
- flower: Mountain Laurel
- bird: Ruffed Grouse
- tree: Eastern Hemlock

Discussion turns to the cultural aspects of the state. Another message is keyed onto the console, the statistics are erased, and the major cities and towns of Pennsylvania appear on the map in their proper geographical locations.

Questions arise about natural topography. Another message and the main rivers, lakes, and mountain ranges are overlaid. A student asks a question, the console is keyed again, and the display answers that the highest point in Pennsylvania is Mount Davis in Somerset County, 3,213 feet above sea level.

Discussion turns to details on the capital city. A few key strokes and the Harrisburg neighborhood is encircled on the map. A few more strokes, and the Harrisburg area is enlarged to fill the entire screen, showing the main streets, the network of superhighways, and the Susquehanna River. Questions on facts about the city are entered one after another through the keyboard and, quick as a telephone conversation, the answers come back:

- latitude: 40° 15′ 43″
- longitude: 70° 52′ 59″
- altitude: 374 feet
- population: in 1960 — 79,697
  in 1970 — 94,226
  located in Dauphin County.

This is information dissemination of the future. In spearheading the development of a United Engineering Information Network, the leadership of the Engineers Joint Council is gradually taking us closer to that day.

[1]Standard mechanical linkages, electrical circuits, chemical glassware.
[2]Design charts, antenna radiation patterns, phase diagrams.
[3]TV test patterns, pictures of laboratory apparatus, diffraction patterns.

Source Indexing and Vocabulary Control

BY B. E. HOLM[1]

Introduction

The Symposium[2] in 1962 proposed to the Engineers Joint Council improvements in source indexing and vocabulary control. The proposals were accepted and a plan for action was available to the engineering societies under which, in less than three years, major, useful progress has been made with scheduled additional improvements. The following is a status report on the impressive and substantial accomplishments made by the engineering societies in source indexing and in vocabulary control. An especially encouraging aspect is the extent of progress in related areas.

Background

Two fundamental and essential steps were proposed. The first was to have all technical articles and books of lasting value abstracted and indexed at the time of publication. The efforts of the author and publisher could be used to the benefit of all the recipients of the technical literature. And as an integral part, EJC arranged for a training course to be given for those who wished to learn the techniques of indexing and abstracting particularly for application to source indexing.

The second essential step was to create a thesaurus of engineering terms that authors, editors, and engineers could use in their work. A thesaurus gives preferred terminology across individual disciplines and the relationship of every term to other terms in the vocabulary. The display provides a form of definition for the terms. This vocabulary control — a means of language organization which assists authors, editors, indexers, and searchers in each phase of information communication has been completed.

First, people were trained. Then the source indexing and vocabulary building began. Let us review each area.

Training in Source Indexing

In March, 1962, two months after the Symposium, the Engineers Joint Council offered its member societies a week-long course at The United Engineering Center in abstracting and coordinate indexing of technical literature. This was a voluntary effort by members of EJC and was attended by 45 engineering society editors and their staffs. Demand by many private companies and government agencies for this training convinced EJC that volunteer training could not continue. EJC entered into an agreement with Battelle Memorial Institute to carry on indexing training on a fee basis. A two-year exclusive endorsement of the courses was given to Battelle in March, 1963, and the agreement was extended in March, 1965. Battelle adheres to EJC specifications and has published a comprehensive set of training materials.

In the past two and one-half years, over 700 specialists have attended. The courses have included a wide geographical area and an extensive cross-section of participants' background. About two-thirds of the attendees, were from the United States, and one-third from other countries; overall, 18 countries have been represented. The courses have been given in 12 cities in the United States and six cities outside the United States in Canada and in Europe. The registrants represent essentially all the fields of science, engineering, liberal arts, fine arts, law, publishing, government, and administration. Nearly 300 questionnaires have been returned to EJC from registrants, giving an evaluation of the course and suggestions for improvement. The suggestions have guided minor revisions, minor because the registrants overwhelmingly endorse the program as *good* to *excellent* as presented.

The Battelle Memorial Institute is to be commended for continuing this not-for-profit effort in bringing to a wide cross-section of potential users solutions to information processing problems. Although 700 registrants do not seem a great many, each of these may represent a missionary returning to his home organization and subsequently influencing many others.

Source Indexing

After the training, journals began source indexing; that is, publishing with the original article an abstract and index terms for that article. EJC also provided the means for dividing the article into logical divisions using links and indicating subject relationships using roles. In this way, and as shown in Figure 1, the author and the editor could assist all those who received the technical article, both secondary sources and individuals, in the recipient's use of the published material.

Source indexing was proposed in January, 1962, and significant progress has been made since then. Figure 2 summarizes the status of source indexing by the Engineers Joint Council and United Engineering Trustees affiliated societies. The number of articles published each year has increased from 7,200 to an expected 7,800 in 1966. Abstracts were included with the original article in 5,100 instances in 1963, increasing to 6,400

[1] E. I. du Pont de Nemours & Company, Inc.
[2] First National Symposium on Engineering Information, Engineers Joint Council, January 1962.

next year. Indexing terms were added to 1,400 articles in 1963, increasing to 2,900 articles in 1966. Use of links and roles has increased modestly over the same period. Table I reveals the increase in all categories.

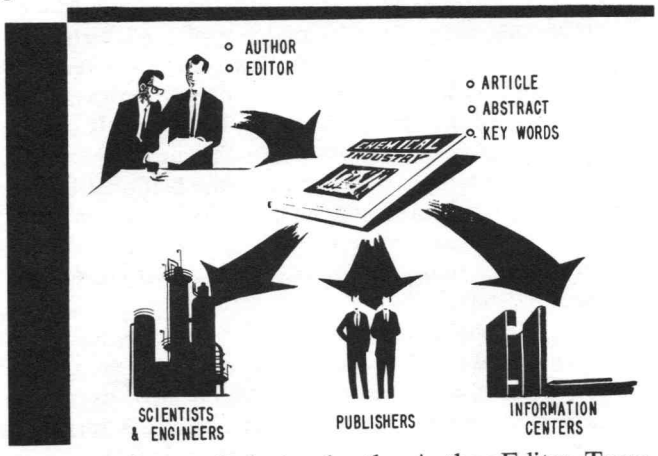

Figure 1. Source Indexing by the Author-Editor Team

In 1963, the Battelle Memorial Institute made a survey of the Engineering Index, which indicated 60,000 articles per year, worldwide, may be the next level of coverage by this secondary source. In addition to the 2,300 EJC-UET articles which included abstracts and indexing terms in 1965, another 1,700 engineering articles published by others included this source indexing material. Therefore, a total of 4,000 articles per year in the engineering field have both abstracts and indexing terms. This represents 7 per cent of the 60,000 published articles. Although significant progress has been made within the society framework, and other sources are now including this material, it is obvious that this progress must continue.

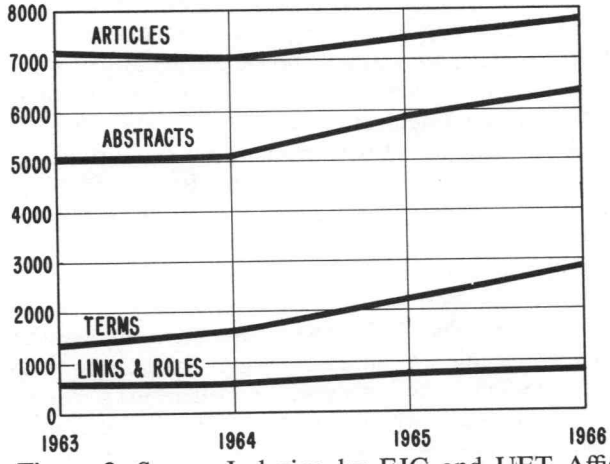

Figure 2. Source Indexing by EJC and UET Affiated Societies

Table II lists the journals which have been doing source indexing for some time, and Table III lists journals which have recently added source indexing material. For example, the ASHRAE Journal began its program in October, 1965. A number of these journals are Canadian and British; it is encouraging that source indexing has attracted a worldwide appeal.

It is interesting to view the various formats used by the journals. Each presents the material in an attempt to stimulate the user in these new methods. Figures 3 a through q give examples of the formats used by various engineering journals.

Table I. — Papers with Abstracts, Index Terms, Links and Roles

	1963	1964	1965	1966
ARTICLES	7200	7080	7530	7830
ABSTRACTS	5120	5190	5950	6420
per cent	71	73	79	82
TERMS	1420	1660	2320	2920
per cent	20	23	31	37
LINKS & ROLES	650	640	790	860
per cent	9	9	10	11

Similar programs are under way in related disciplines. The American Institute of Physics, to cite one example, has had a documentation research project for many years and all 10,000 articles per year have abstracts.

The publication, APPLIED PHYSICS LETTERS, includes indexing terms. Three other journals published in the United States and in Europe are adding indexing terms. Eight major physics journals are asking their authors to help by filling out an aid-to-indexing form, listing the major ideas included in their physics research papers. Questions on the form are in terms of *properties* of *objects* determined by certain *methods*.

Previously, compiling an annual index to a journal was often a rush assignment at the end of the year, given to a nontechnical person; but presently, since each article has an abstract and indexing terms pub-

Table II. — Journals Practicing Source Indexing for Some Time

TITLE	PUBLISHER
AIChE JOURNAL	AIChE
AGRICULTURAL ENGINEERING	ASAE
ASCE PROCEEDINGS	ASCE
CHEMICAL ENGINEERING	McGRAW-HILL
CHEMICAL ENGINEERING PROGRESS	AIChE
CIVIL ENGINEERING	ASCE
ELECTRO-TECHNOLOGY	CONOVER-MAST
INTERNATIONAL CHEMICAL ENGINEERING	AIChE
JOURNAL OF AMERICAN CONCRETE INSTITUTE	ACI
JOURNAL OF PETROLEUM TECHNOLOGY	AIME-SPE
JOURNAL OF PRESTRESSED CONCRETE INSTITUTE	PCI
MATERIALS RESEARCH & STANDARDS	ASTM
MINING ENGINEERING	AIME-SME
PETROLEUM REFINER (COORDINATE INDEX)	GULF PUBLISHING CO.
SOCIETY OF PETROLEUM ENGINEERS JOURNAL	SPE
SYMPOSIUM SERIES	AIChE
THE SAE JOURNAL (COORDINATE INDEX)	SAE

Table III. — Journals That Have Recently Started Source Indexing

AACE BULLETIN
ASHRAE JOURNAL
CANADIAN MINING AND METALLURGICAL BULLETIN
ENGINEERING JOURNAL
FIRE TECHNOLOGY
IEEE TRANSACTIONS
ELECTRONIC COMPUTERS
COMMUNICATIONS TECHNOLOGY
ENGINEERING WRITING AND SPEECH
ENGINEERING IN MEDICINE AND BIOLOGY
PARTS, MATERIALS, AND PACKAGING
JOURNAL OF THE ELECTROCHEMICAL SOCIETY
JOURNAL OF METALS
MAGAZINE OF CONCRETE RESEARCH
PHYSICS AND CHEMISTRY OF GLASSES
STRUCTURAL CONCRETE

lished, the preparation of the annual index is a simple procedure, which provides technical coverage in depth.

A worthwhile program such as this often breeds other benefits. A colleague, Dr. J. F. Walker, the author of the American Chemical Society monograph, *Formaldehyde,* decided to use some new information processing concepts with the object of obtaining a more informative and compact book index. Consequently, a novel index was included in this book, published by Reinhold, which should serve as a stimulus to other publishers in considering modern information processing techniques in the book field.

Steady progress has been made in source indexing as all of the sponsoring engineering societies have endorsed the program and plan to participate as obtainable personnel and ready funds permit. Because EJC realizes that many societies are not able to implement this proposal now, it has submitted a proposal to the National Science Foundation for funds to assist some of them in getting started with source indexing.

Thesaurus of Engineering Terms

Parallel with developments in training and source indexing, EJC began the program toward vocabulary control. The first step was to assist the Defense Documentation Center (then ASTIA) in revision of its thesaurus. EJC submitted a proposal to the National Science Foundation for the study of the existing engineering terminology. The first step of the work, begun during the summer of 1962, was to gather from the societies subject heading lists, classification lists, indexes, and other vocabularies to form a comprehensive vocabulary pool. Terms numbering 119,000 were contributed by different groups, including the engineering societies, National Aeronautics and Space Administration, the Atomic Energy Commission, The Engineering Index, and The Engineering Societies Library. The terms were keypunched and a master word list was developed of 14,000 terms selected because they were contributed by two or more sources.

The terms were analyzed to resolve ambiguity in meaning, develop and record cross references, provide explanatory notes and definitions, and establish the necessary relationships. Representing each of the fields covered, 131 engineers, through voluntary effort totaling 130 man-weeks, completed this fantastic effort in 27 weeks. This indicates the interest from the engineering profession in banding together for the accomplishment of necessary steps toward a major goal. This terminology study concluded that there was sufficient overlap of terminology within the engineering profession to develop a thesaurus of interest to the entire discipline. It was decided to go ahead and produce a thesaurus. A supplementary proposal was submitted to the National Science Foundation. to cover the final editing and converting into camera-ready copy for publishing. The resulting thesaurus was published by the Engineers Joint Council in June, 1964.

This Thesaurus contains 10,515 unique terms arranged alphabetically and displayed to show synonymous, hierarchical, and other relationships, as well as necessary definitions. It has as its objectives service to engineers in three ways: (1) assisting indexers in indexing more fully, at different levels of generality, and from different technical viewpoints, (2) aiding the information searcher in phrasing effective inquiries using all the appropriate terms of the engineering vocabulary, (3) assisting writers, editors, and others in more accurately expressing technical information in accordance with current usage of engineering language.

The Thesaurus was offered for sale in two versions. The more popular was the printed volume which sold at a prepublication price of $10, and postpublication at the current price of $15. To date, 6,000 copies have been sold, and the book is in its second printing. The same material was offered on magnetic tape for a price of $500. Five copies have been sold and two donated.

The past five years have seen the emergence of many thesauri. A system of vocabulary control is a logical and necessary step in any information process, whether it be the management of a personal collection of 35 mm. slides, the management of the Defense Documentation Center, or the Engineering Societies Library. Notable among the long list of new thesauri are those published by the Bureau of Reclamation, the Bureau of Ships, and the Pulp and Paper Research Institute of Canada.

The American Institute of Chemical Engineers published its thesaurus in 1961. It serves as the model for specialized thesauri being considered by other engineering societies. The EJC Thesaurus gives the general terms applicable to all engineering. Specialized engineering thesauri can list those detailed terms necessary for each discipline which would not interest other areas.

Many companies have created and are using in-house systems based on these published efforts; and in a sense, a network of vocabulary control centers is emerging. The EJC Thesaurus can serve as the focal point for vocabulary control in the engineering field. Similar efforts will produce recognized thesauri in other major areas.

Work on language is never done as long as technological progress is being made. Therefore, as soon as the Thesaurus was printed, EJC began a program for keeping it current. EJC asked every engineering society and every purchaser of the Thesaurus to submit sug-

gestions for improvement; such as, additional terms, changes in references, additional cross references, and others. An engineering vocabulary panel was established to administer the continuing effort. Organizations have offered suggested term listings on magnetic tape, in punched cards, or printed, ranging from 325 terms submitted by Volvo in Sweden, to 10,000 subject headings on computer tape for the United States Atomic Energy Commission. An editing committee has been established to deal with this input material; a committee on rules is setting the mechanisms for updating; engineering societies are submitting the names of volunteers to work in the subject areas. It is scheduled that questionnaires will come in and be analyzed, the rules established, and the editing procedures completed so that during the first quarter of 1966, the separate subject area groups can begin their analyses. The second edition of the EJC Thesaurus should be published in the fourth quarter of 1966.

Education a Continuing Process

Three years and nine months ago, a plan of action was proposed and accepted. Engineering Society editors and users have been trained in the new methods, source indexing is steadily increasing, a firm foundation for an engineering vocabulary has been laid and is being strengthened for more progress in the coming years. Corollary benefits have appeared in better annual indexes and improvements and savings noted for the secondary publications. The engineering field has assessed the information problem, has planned a program, implemented the first steps, and scheduled ways and means looking toward continuing progress.

Accession No. _____

"Estimating Capital Equipment Construction Costs with the Learning Curve," Hirschmann, W. B., *AACE Bulletin*, Vol. 7, No. 3, p. 98 (September, 1965).

AACE BULLETIN KEYWORD CONCEPTS

— Link A —

Active (8)	**Passive (9)**	**Means or Methods (10)**
Estimating	Capital Costs	Learning Curves
Predicting	Construction Costs	
	Equipment Costs	

Independent Variables (6)	**Dependent Variables (7)**
Number of Units	Cost Per Unit
Units Produced	

— Link B —

Active (8)	**Passive (9)**	**Means or Methods (10)**
Characterizing	Progress	Learning Curves
	Technical Progress	

Abstract:
The background of learning curves is discussed, along with the use of learning curves for predicting capital costs, operating costs, and manpower requirements. The application of learning curves to prediction of capital equipment construction costs is pointed out. An example of the application of learning curves to the construction of fluid catalytic cracking units is cited.

AACE BULLETIN

INFORMATION RETRIEVAL ABSTRACTS

These abstracts of Journal articles are provided to furnish a literature research tool for the engineer. They are printed in a format that should lend itself to maintenance in a 3 x 5-inch card-index file. For purposes of information retrieval, in a simple system, each abstract should be clipped and mounted on an index card. Each card should then be assigned an index number, in accordance with the user's own system, to assure ease of finding. This number should be entered on the card. Separate cards should be made out for each key word appearing in bold face in the abstract and the index number entered on each such card. If a key word already has an existing card, the index number should be added to that card. Key word cards should be filed alphabetically; abstract cards, numerically, by index number. Looking for a key word, then, would lead the searcher to one, or more, index numbers that would refer to those cards that bear abstracts, article titles, authors' names, and dates of publication of pertient articles.

Harman, C. M. and Macduff, J. N.: An Experimental Method for Determination of Noise Attenuation in Air Ducts.
ASHRAE Journal, October 1965, Vol. 7, No. 10, p. 43.

Index No. _____

Key Words: Noise (sound); Air ducts; Sound (pulse); Attenuation; Fourier transform; Computer (digital).

ASHRAE JOURNAL

A Marketing—8, Design—8, Garden Tractors—9, Lawn Tractors—9, Hydrostatic Drives—9, Lawn Mowers—9. **65-019**

B Safety—8, Garden Tractors—9, ASAE—10, ASA—10, Standards —10.

Market for lawn and garden tractors and outdoor power equipment is predicted and safety of such equipment is considered through standardization.

Growing Market for Lawn and Garden Tractors and Outdoor Power Equipment, R. H. Witt and B. J. Lamp

AGRICULTURAL ENGINEERING 46: (8) 436-437, 447, August 1965.

Figure 3. Examples of Source Indexing
(a) AACE Bulletin, (b) ASHRAE Journal, (c) Agricultural Engineering, (d) Chemical Engineering, (e) Chemical Engineering Progress, (f) Journal of Metals, (g) Journal of Petroleum Technology, (h) Transactions on Electronic Computers, (i) Hydrocarbon Processing & Petroleum Refining, (j) Electro-Technology, (k) Journal of the American Concrete Institute, (l) Fire Technology, (m) The Canadian Mining and Metallurgical Bulletin, (n) Journal of the Sanitary Engineering Division, ASCE, (o) Mining Engineering, (p) Materials Research and Standards, (q) The SAE Journal

Key Concepts for This Article

Active (8)	Passive (9)	Means/Methods (10)
Storage*	Articles	Concept coordination*
Retrieval*	Information*	Indexing (file)*
	Literature	Keywords
	Publications*	Roles
		Links (indexing)

(Words in bold are role indicators, numbers correspond to EJC-AIChE system except for Role 8 modification. Asterisks mark key concepts suggested for indexing. Others added to improve reading as abstract. Indexing described in *Chem. Eng.*, Oct. 11, 1965, p 187; or order Key Concept reprint, 50¢, using Reader Service Postcard.)

October 11, 1965—Chemical Engineering

CHEMICAL ENGINEERING

CEP Key Word Index/Abstracts

For more details on the use of these Key Words and the A.I.Ch.E. Information Retrieval Program, see Chemical Engineering Progress, p. 88, August, 1964.

What does it cost to desulfurize fuel oil?, Galstaun, L. S., B. J. Steigerwald, J. H. Ludwig, and H. R. Garrison, Chem. Eng. Progr., 61, p. 49 (September, 1965).

Key Words: A. Processing-7, 8, Desulfurization-7, 8, Hydrodesulfurization-7, 8, Hydrotreating-7, 8, Conversion-7, 8. Specifications-6, 8, Oils-1, 9, Fuel Oils-1, 9, Residual Oils-1, 9, Crudes-1, 9, California-0, Kuwait-0, Refineries-10, Linear Programming-10, Models-10, Sulfur-3, 6, Sulfur Dioxide-6, Oxides/Inorganic/-6, Concentrations-6, Restrictions-6, Capital-6, 7, Capacity-7, Costs-7, Pricing-7, Contamination/Process/-7, Pollution-7, Viscosity-7, Physical Properties-7, Properties/Characteristics/-7, Hydrogen-1.

Abstract: Combustion of residual fuel oil is a significant source of sulfur oxide emissions to the atmosphere in some localities. The results of an economic study of the cost of producing low sulfur fuel oil are discussed. A linear programming analysis was used to evaluate possible refinery schemes. Manufacture of low sulfur residual fuel oil requires an incentive pricing of $0.42 to $0.65/bbl. above fuel oil produced without sulfur restriction.

CHEMICAL ENGINEERING PROGRESS

Iron-Base Superalloys for Turbine Engines, Amedee Roy, Frederick A. Hagen, and John M. Corwin, JOURNAL OF METALS, 1965, vol. 17, no. 9, pp. 934-39.

Abstract: The development of low-cost, high-temperature, iron-base alloys for Chrysler Corp.'s new gas turbine engines is discussed. These two alloys are CRM-6D and CRM-15D. Also described are laboratory and field evaluations of these materials which indicate performance equivalent or superior to some of the more expensive aircraft-type superalloys at temperatures up to at least 1500°F.

Keywords: A. Development 8; Evaluation 8; Iron alloys 2,9; CRM-6D 2,9; CRM-15D 2,9; High-temperature 0; Low-cost 0; Gas turbine engines 4; Chrysler Corp. 9.

JOURNAL OF METALS

Recovering Oil From Shale With Nuclear Explosives, D. B. Lombard, *Jour. Pet. Tech.* (Aug., 1965) 877-882.

Abstract: Nuclear explosives can be used to break large volumes of oil shale in place at depth, where deposits are thick. The diameter of the region (chimney) of shale broken by a nuclear explosion can be as much as hundreds of feet. The height is at least double the diameter. For example, a 20-kt detonation at a depth of 2,000 ft will break about 800,000 tons. Radioactivity should not pose any impossible problems. Cost of breaking shale with nuclear explosives would range from less than $.35 to more than $1.20/bbl of oil for recovery of 25 gal/ton. Basic features for a plan of in situ retorting are discussed, and a relatively small scale non-nuclear in situ retorting experiment is proposed.

Keywords: Atomic Energy Commission, Combustion, Economics, Explosives, Heat, Mining, Nuclear, Oil, Oil shale, Permeability, Radioactivity, Recovery, Reservoir, Retorting, Rock, Shale oil, Stimulation, Thermal.

JOURNAL OF PETROLEUM TECHNOLOGY

Accession No.

Mileto, F., and G. Putzolu: AVERAGE VALUES OF QUANTITIES APPEARING IN MULTIPLE OUTPUT BOOLEAN MINIMIZATION, Laboratorio Ricerche Elettroniche Olivetti, Pregnana Milanese, Milan, Italy.
IEEE TRANS. ON ELECTRONIC COMPUTERS, 14-4, August 1965, pp 542-552

In connection with the problem of two level minimization of systems of Boolean functions formulas are obtained for the following statistical quantities: average number of k-cubes, prime k-cubes and essential k-cubes of a system of Boolean functions. The parameters appearing in the formulas are: number of variables, number of functions of the system, number of "one" vertices of each function. Numerical evaluations are given; increasing by one the number of variables n of a system of m functions roughly results in multiplying the average numbers of cubes and prime cubes by a factor of about 2.2 to 2.3. The ratio of the average numbers of essential cubes and prime cubes rapidly decreases increasing n or m, so that the minimization algorithms, which obtain the essential cubes before the prime cubes, seem statistically unsuitable to solve "large" minimization problems. The average occupation memory occurring in Quine, McCluskey, and Bartee algorithms is also evaluated. Its rate of increase with the number of variables is about 2.5.

Minimization
Boolean functions
Statistical quantities

TRANSACTIONS ON ELECTRONIC COMPUTERS

Figure 3. (cont.)

A QUICK LOOK AT THIS ISSUE

☑ **Check those you want to read first.**

✂ **Clip those you want to add to your key word file.**

Special Report

How Engineers Can Keep Up-to-Date

Just What is Engineering Obsolescence? . . . Is "engineering obsolescence" a real problem, or just another hackneyed term? What is the evidence that the older engineer will be surpassed by the younger man if he does not have a program of continuing education? Here's what an extensive study shows. Page 98.

Indexing Terms: Analysis-8, Continuing-9, Determination-8, Education-9, Engineering-9, Equations-10, Evaluation-8, Formulas-10, Identification-8, Investigation-10, Obsolescence-9, Study-10, Survey-10.
Ref: Vervalin, Charles H., HP/PR 44, No. 8, 98-101 (1965).

Other Technical Articles

Piping Tierod Design Made Simple . . . How do you design tierods for pipe joints that tend to pull apart under internal pressure, such as slip joints or bellows expansion joints? Most piping designers recognize the need, but what are the design requirements? For a set of simple tables that will enable you to select the right sized tierod, see page 118.

Indexing Terms: Anchors-4, Couplers-4, Design-8, Expansion-4, Fasteners-4, Gimbals-4, Joints-4, Piping-4, Pressure-4, Rods-9, Sizing-7,8, Sleeves-4, Tables/Tabular/-10, Tierods-9.
Ref: Doyle, W. E., HP/PR 44, No. 8, 118-120 (1965).

HYDROCARBON PROCESSING & PETROLEUM REFINING

IN THIS ISSUE

AUGUST • 1965

See opposite and page 138 for reprints available. Circle 938 on card at end of book for a copy of our Subject Classification

○ **CIRCUIT DESIGN** — Filter — E-T, Aug 1965 p 34 4 pp

NARROW-BAND CRYSTAL FILTER TRANSFORMATIONS

By J. Lang, Lenkurt Electric Co., Inc., San Carlos, Calif. A method of designing narrow-band crystal filters by a series of network transformations is presented—step by step. The basic transformations are explained, and explicit design equations are given for several lattice networks. *An E-T Reprint.*

△ **TEST AND MEASUREMENT** — Testing of Components — E-T, Aug 1965 p 50 3 pp

TESTING COMPONENTS BY THERMAL PLOTTER

By G. Revesz and B. G. Marks, Philco Corp., Willow Grove, Pa. The thermal emission of a component reveals much about its condition. Instruments for relating thermal emission to spatial configuration are described, and their use is illustrated through examples.

□ **ECONOMIC AND SOCIAL CONSIDERATIONS** — Program Organization — E-T, Aug 1965 p 57 9 pp

ORGANIZING FOR PRODUCT RELIABILITY

By T. A. Daly, Westinghouse Electric Corp., Pittsburgh, Pa. The interdepartmental procedures and definitions of responsibility necessary to achieve product reliability can be quite complex in a large organization. The engineering department must take the initiative and serve as the reference center. *An E-T Reprint.*

ELECTRO-TECHNOLOGY

Figure 3. (cont.)

KEY WORDS: accelerator: ACI committee report; admixture; air entrainment; calcium chloride; cold weather concreting; compressive strength; concrete; curing; form removal; freezing and thawing; heating materials; insulated forms; protection; subgrade preparation; temperature.

SYNOPSIS: The general requirements for producing satisfactory concrete during cold weather are discussed, as are methods for achieving these requirements. It is emphasized that for many structural concretes, protection considerably in excess of that required to insure freedom from damage by early freezing is required to assure safe development of strength. Accelerators, keeping of temperature records, heating of materials, subgrade preparation, protective insulating coverings, heated enclosures, curing, and form removal are discussed. Supplementary material on the effect of curing temperatures on concrete strength is referenced in authoritative sources. A list of selected references is included.

REFERENCE: ACI Committee 306, "Proposed ACI Standard Recommended Practice for Cold Weather Concreting," ACI JOURNAL, Proceedings V. 62, No. 9, Sept. 1965, pp. 1009-1036.

JOURNAL OF THE AMERICAN CONCRETE INSTITUTE

EDITOR'S NOTE: For information on how to set up your own abstract file and information retrieval system incorporating abstracts from FIRE TECHNOLOGY and other sources, see the article, "Information Retrieval — Three Practical Methods," on page 69 of the February 1965 issue. In clipping these abstracts for mounting on file cards, the reverse side of each page should be photocopied to retain the abstracts appearing thereon.

FIRE TECHNOLOGY
August, 1965

NFPA Lib. Class. 4

KEY WORDS: fires, fire research, fire protection engineering, theory of fire, fire fundamentals.

ABSTRACT: The application of modern engineering science to fire problems holds great promise for the future. Few investigations of the fire problem have been of a fundamental nature and consequently few startling developments have appeared in construction for fire resistance, detection of fires, and fire extinguishment. In the area of free burning fire, the studies required for the understanding of the phenomena have hardly been initiated. More fundamental research in fire technology is urged.

REFERENCE: "Fire Development Theory — An Overview," Howard W. Emmons, *Fire Technology*, Vol. 1, No. 3 (August 1965), pp. 175–181.

Abs: 65–30, Fire Technology, August 1965; Boston, Mass.

Hydrometallurgical Treatment of Oxidized Nickel-Cobalt Concentrate, by D. Maschmeyer and B. Benson; C.I.M. Bulletin, Vol. 58, No. 641, pp. 931-938, 1965.

Abstract: The cobalt production of the Chemical Metallurgical Division of Sherritt Gordon Mines Limited was supplemented, from May, 1962, to June, 1964, by processing 3,500 tons of a calcined cobalt-nickel concentrate. This paper describes the reduction roast - aqueous sulphuric acid leach process and the operating practices employed in recovering cobalt, nickel and copper from this oxidized by-product of a lead-copper operation. Incorporated in this paper is a description of how this process was integrated with the existing ammonia leach - hydrogen reduction process for the recovery of nickel and with the soluble cobaltic ammine process for the recovery of cobalt.

Key Words: Hydrometallurgy, Nickel, Cobalt, Leaching, Hydrogen reduction, Reduction, Calcine process, Acid leaching, Furnace, Roaster, Oxidation, Autoclave, Iron removal, Copper removal, Filtration.

THE CANADIAN MINING AND METALLURGICAL BULLETIN

Figure 3. (cont.)

JOURNAL OF THE SANITARY ENGINEERING DIVISION

KEY WORDS: algae; closed-cycle ecological systems; environmental engineering; life support systems; sanitary engineering; waste conversion; waste disposal

ABSTRACT: Long term life support requires the use of a closed ecological system. The attainable degree of closure is determined by the extent of conversion achieved in the waste recovery system. Organisms used in such systems must be reliable, useful, and integrable. Strictly speaking, a completely closed ecological system implies a photosynthetic component, because oxygen is produced biologically only through photosynthesis. However, the same result can be attained by substituting electrolysis of water for photosynthesis in the production of oxygen. Photosynthetic systems generally have algae as the green plants, whereas nonphotosynthetic systems use bacteria of the genus Hydrogenomanas as the key organism. An integrated life support system consisting of a mammal (mouse or mice), algae, and bacteria, and named "Microterella" by the writers, was developed and used by the writers to demonstrate that closed ecological systems (in the strict sense) are suitable for life support in space. The development of the Algatron, a growth unit of which a mechanically rotated algal-bacterial culture is an essential feature, considerably enhances the practical feasibility of the Microterella system.

REFERENCE: Oswald, William J., Golueke, Clarence G., and Horning, D. O., "Closed Ecological Systems," Journal of the Sanitary Engineering Division, ASCE, Vol. 91, No. SA4, Proc. Paper 4445, August, 1965, pp. 23-46.

ABSTRACTS

Southwest Copper—A Position Survey by John V. Beall, photographs by William F. Haddon, p. 77.

ME, October 1965

A brief description is given of the scope of operations and expansion plans of the 17 operating mines in the Southwest. The area covered is Arizona and Chino, N. M., and Cananea, Sonora, Mexico. Operating data for each property are given in a complete table. There is a discussion of the dump leaching process and a table of some operating data. The article is accompanied by four pages of color photographs.

Key Words: Southwest, copper, mining, leaching, beneficiation, Cananea, Morenci, Copper Queen, New Cornelia, Chino, Ray, Miami, Castle Dome, Copper Cities, Inspiration, Christmas, Magma, San Manuel, Silver Bell, Mission, Bagdad, Pima, Esperanza, Mineral Park, Twin Buttes.

Mesabi Enters A New Era by Paul C. Merritt, p. 93

ME, October 1965

The rapid growth of the taconite industry in Minnesota during the past year has been characterized by numerous announcements of newly proposed plants or the expansion of those already existing on the Mesabi Range. In a series of up-dating reports, the essential aspects of each plant is described with emphasis on the mining and processing methods now envisioned. Also summarized are the economic outlook for Minnesota taconite and the important role played by the Taconite Amendment which brought these new developments about.

Key Words: Taconite, iron ore, agglomeration, pelletizing, open pit mining, haulage equipment, Minnesota, Mesabi Range, Erie Mining, Butler Taconite, National Steel Pellet Plant, Eveleth Taconite, U.S. Steel, Reserve Mining.

MINING ENGINEERING

OCTOBER 1965, MINING ENGINEERING—141

KEY WORDS: performance, double glazed window units, windows, sealers, thermal cycling, testing, humidity, exposure, dew point

ABSTRACT: A test program for evaluating double-glazed window units is described and performance specifications are proposed. Preliminary dew point temperature and seal leakage tests are performed on fourteen specimens. The lot is rejected if any specimen has a dew point temperature above 0 F or has a seal leak. Groups of four specimens are subjected to the following tests, one group to each test: thermal cycling, 120 to 20 F—500 cycles; static temperature-humidity, 110 F, 90 per cent relative humidity—200 days, and outdoor exposure, Fort Lauderdale —365 days. The lot is rejected if more than two units have a dew point temperature >0 deg F. Units employing both organic and inorganic sealants have been tested. The best performance, in both acceptance and glazing tests, was shown by vulcanized extruded- and all glass-sealed units, the poorest by polysulfide rubber-sealed units.

REFERENCE: R. J. Mazzoni and L. K. King, "Performance of Double-Glazed Units in Accelerated and Service Tests," *Materials Research & Standards*, Vol. 5, No. 10, October, 1965, pp. 517–524.

KEY WORDS: light flash, impact, fluid jet, surfaces, gases, cavitation

ABSTRACT: Characteristics of the flash of light produced as the leading surface of a high velocity liquid jet strikes a surface were investigated, and the cause of this phenomena was determined. The intensity of the flash is dependent upon the ambient gas present and the shape of the leading surface, but is independent of specimen material, specimen surface contaminants, and type of fluid. Spectroscopic measurements show the radiation is continuous throughout the spectrum. Mechanical compression and consequent heating of gas trapped between the fluid jet and the solid surface is proposed as the cause of this light flash. This conclusion is supported by the observation that when an aluminum foil sheet is interposed between the fluid jet and the specimen surface, the flash of light still occurs at the specimen surface, rather than at the foil as an electronic mechanism would predict.

REFERENCE: S. M. DeCorso and R. E. Kothmann, "Characteristics of the Light Flash Produced Upon Impact of a Liquid with a Surface," *Materials Research & Standards*, Vol. 5, No. 10, October, 1965, pp. 525–528.

MATERIALS RESEARCH AND STANDARDS

Figure 3. (cont.)

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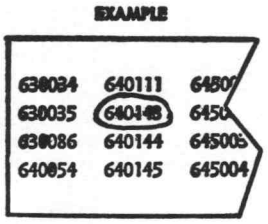

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by the statistical analysis of a series of repeat measurements on two typical lots of passenger tires is given in the third part.

650570 (P-6) **Fail-Operative Stability Augmentation System with Self-Test Capability.** H. Moreines, R. Sellite, and A. Kirchhein, Bendix Corp., Eclipse-Pioneer Div. A fail-operative stability augmentation system for the C141 jet transport aircraft yaw control axis is described. Triple-redundant sensors and signalling are used in conjunction with a dual-output, monitored servo system.

650572 (P-6) **Automatic Landing Systems Mechanization – Series or Parallel Servos?** D. P. Hoffman and H. Kawana, North Amer. Aviation, Inc. A review of several studies and their results, conducted in an effort to determine the most advantageous form of outer loop control mechanization for use in high-performance flight control systems, has indicated that the series servo concept has considerable merit in contrast to the similar parallel servo mechanization. Results of both analytical and simulator studies are presented. Other all aspects of the system design are also described.

O'Hern, North Amer. Aviation, Inc., Autonetics Div. Increasing attention is being devoted to the application of various redundancy techniques to flight-control systems. The application of immediate concern in this paper is the important class of tactical military aircraft: its characteristics and its advantages.

650575 (P-6) **Hydrologic Redundant Systems.** D. Wood, Hydraulic Res. & Mfg. Co. This paper considers redundant systems starting with overall flight control system requirements and then proceeds via

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THE SAE JOURNAL

Figure 3. (concluded)

Libraries -- An Ancient Link in a Modern Information Chain

BY EUGENE B. JACKSON[1]

Libraries have a long and distinguished history, a fact testified to, especially by their past contributions in the area of information processing. And the EJC system envisioning the infusion of greater depth, coordination, and systematization in the future of the engineering library points up the potentiality for their increased usefulness.

The first libraries established in the Near East about 3500 B.C., were repositories of clay tablets or papyrus scrolls that recorded information such as vital statistics, boundaries of land, and political and meteorological events. A significant part of the information was in the field of what we would today call civil engineering. The early librarians were experts in their specified subjects with literature as a side-line interest.

Currently, we have subject specialists who have come to realize that importance of technical literature at an advanced stage in their professional careers. They see the part it can play, and is playing, in the solution of engineering problems and the urgency for such material to be available in a convenient form when it is needed.

The impression has arisen that only subject specialists can think of literature in an active rather than in a passive sense, but one can recall that special libraries have been conducting active literature assistance since about 1909. This is my definition (1)[2] of a special library:

A special library is one which is engaged in activities serving the technical information needs of a special clientele and which departs from standard library procedures and uses nonconventional sources and methods as necessary to fill those needs.

Long before the concept of mechanized selective dissemination of information, libraries were routing material to their technical men on the basis of subject interest and calling to their attention specific articles expected to be useful. Granted that this primitive effort was quantitatively low in contrast to the present EJC prospectus, yet that program should be welcomed as one additional aid for those librarians who must avail themselves of a "symphony of sources" to fill their organizations' information requirements.

The library services of an industrial or other technical organization are made up of certain assets — physical facilities, personnel, financial resources, patents, franchises, and internally generated information and the intent is to exploit all of these in the fullfillment of the organization's technical and economic objectives. The assertion is emphasized that the typical engineering activity adds the leavening of its privately developed information to a larger mass of external data to arrive at new, private information, with the library as the traditional catalyst in this process. This phenomenon which we call "the iceberg effect" is illustrated in Figure 1.

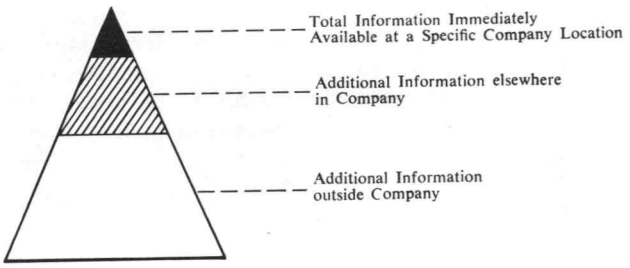
Total Information Immediately Available at a Specific Company Location
Additional Information elsewhere in Company
Additional Information outside Company

Figure 1. The Iceberg Effect

What are the characteristics of special librarianship now serving the engineering community? The studies (2) of Professor Anthony Kruzas, University of Michigan, along with a subsequent statistical study he prepared with an Office of Education grant enable us to have a clearer picture of the magnitude of this effort. Kruzas, found that more than a quarter or 2,500 of the 8,533 special libraries are in the subject fields of science and technology. (The literature of science and technology collections are intimately intertwined.)

Science and technology is the major subject area of one half of the company libraries, one quarter of the college and university department libraries, one quarter of the Government Agency libraries, and one eighth of the public library departments.

To learn something about the organizations sponsoring such libraries, a cross check was made of the Kruzas Directory with *Fortune's* latest listing of 500 industrials. Over half had libraries (52.4% or 262 firms.) These important firms in fact, were the sponsors of just under half (42.8%) of all the U. S. industrial libraries (927 of 2163 reported).

Now that we have emphasized the importance of the industrial or company library in the consideration of the total engineering library picture, it is helpful to define a typical company library. Table I shows the relatively small size of the collection indicating a need for outside assistance such as might be obtained from a Coordinated Engineering Information System. The data also indicate the logic of that system having a focus in the New York metropolitan area with the Engineering Societies Library as its hub.

[1]Director of Information Retrieval and Library Services, International Business Machines Corporation.
[2]See references at end of paper.

Utilization of the projected Engineering Information System is made still more meaningful when it is viewed in the light of the present annual investment that the industrial, college and university, governmental and public library communities presently have in the United States 2,500 science and technology libraries. The annual investment is in the order of $150 million, evenly divided between staff salaries and materials costs, but excluding capital equipment, rental, utilities etc. with exclusions. Relevant calculations are shown below.[3] A look at the international scene shows that there is a far larger investment and a greater need to maximize information utilization. The cross check of *Fortune's* two industrial lists and the Kruzas Directory, shows that there are 67 blue-ribbon firms that have what I have chosen to call "library pairs," that is, library systems, operating concurrently in North America and Europe, involving over 552 libraries.

I have been fortunate enough to have had experience with certain international aspects of one major industrial firm's library system and am gaining familiarity with that of another. Both examples have impressed me with the need of maximum coordination, standardization, and compatibility. The law, the language, security, and other inevitable considerations are going to hamper communications between the "library pairs" such that all the aid engineering systems design affords will indeed be welcome.

Figure 2 is a diagram of the Engineering Information model that has been conceived by others in the EJC structure and it would appear to have much relevance here. However, it relates only to the domestic engineering information situation, whereas, for 67 international activities the picture must be more complex.

Table I. — A Typical Company Library[1]

Sponsor — Listed in **Fortune's** 500 Industrials	
Founded — Since 1940	
Location — New York Metropolitan Area	
Size of Collection — Up to 4,000 Volumes	
Periodical Subscriptions — Up to 200 Titles	
Size of Staff — 4.2 Persons (Prof. — 1.6; Nonprof. — 2.6)	

[1]Sources: Fortune, July, 1965
Kruzas 1965

[3]The figure of $150 million was arrived at as follows:

	1748 Libs. in Kruzas		752 Libs. not in Kruzas (his averages used)	
Professional Staff	3,608	+	(752 x 1.6 each) 1202	= 4.810 prof.
Nonprofessional Staff	5,234	+	(752 x 2.6 each) 1955	= 7.190 nonprof.

My estimate of annual professional salary = $8,000
My estimate of annual non-professional salary = $4,500
Salary costs = (4,810) ($8,000) + (7,190) ($4.500) = $70,835,000
Material costs approximate salary costs = 70,835,000
Total = $141,670,000

(Exclusions as noted in the text.)

Case Study General Motors

As a sample of the type of chart that may eventually be married to the Engineering Information Network Model, Figure 3 shows the principal information sources utilized in the General Motors Corporation as these will appear in the January, 1966, issue of LIBRARY TRENDS. That issue is to be devoted to the services rendered by the entire library community to industry and includes a case study on General Motors Research Laboratories Library as the source of the chart at hand (4). Certain results of the General Motors study were relevant to the symposium theme. Despite an aggressive literature acquisition program dating back to 1917, it was still necessary to borrow 1,100 items from outside the Corporation in 1964. Approximately a quarter of the requests originated with the engineering departments of the Laboratory. The significant consideration on the subject-matter breakdown of the request load for an industrial research library was that 20 per cent were from completely outside the fields of engineering and science. Over half the material required was from periodicals and 60 per cent of the material requested had been published since 1959.

No Library Is an Island

It is impractical for an engineering library to be self-sufficient — it will be requesting material from outside the fields of its major specialization; and it will be using recent information. These observations point to the fact that the EJC program could not provide the entire support for the engineering libraries (let alone supersede them), but its emphasis on *currency*, on *comprehensiveness*, and on *flexibility* in handling detailed inquiries will inevitably be a major help to the librarian in carrying out his basic functions. These are the acquiring, processing, disseminating, and utilizing engineering information as they are required to insure the achievement of the sponsor's technical objectives. In other words, the engineering librarian will remain the merchandiser of information, with the EJC network serving as a major wholesaler and distributor.

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(1.) Jackson, Eugene B. Special libraries (to 1980) **Library Trends,** 10:209, October, 1961.

(2.) Kruzas, Anthony T. Directory of special libraries and information centers. First edition. Detroit, Gale Research Company, c1963. 767p.

(3.) Kruzas, Anthony T. Special libraries and information centers, a statistical report on the special library resources in the United States. Detroit, Gale Research Company, (1965) 42p.

(4.) Jackson, Eugene B. General Motors Research Laboratories Library, **Library Trends,** Vol. 14, pp. 353-361, January 1966.

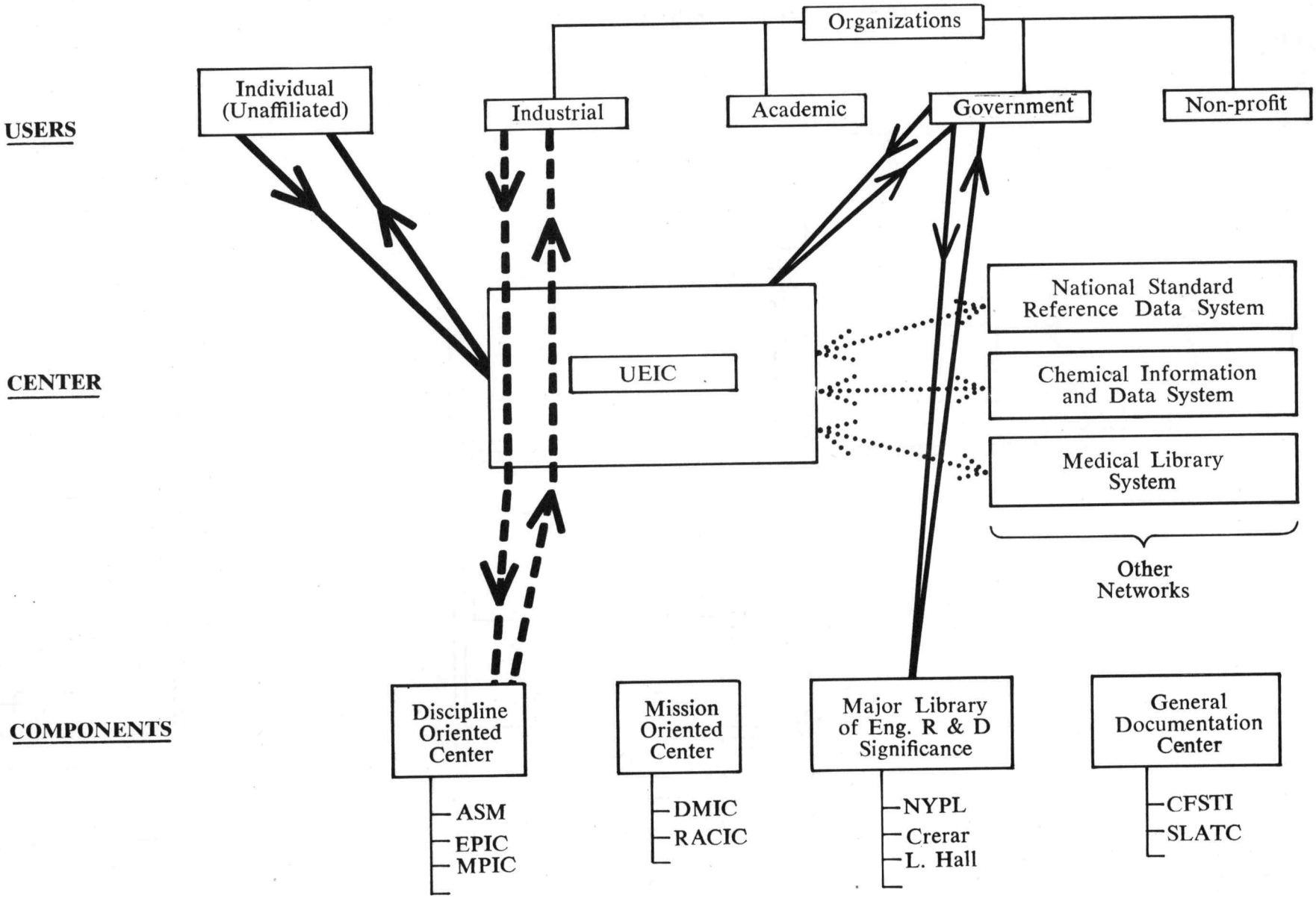

Figure 2. Engineering Information Network Model

The On-Line Intellectual Community

Luncheon Address

BY J. C. R. LICKLIDER[1]

The title, "The On-Line Intellectual Community," needs definition. *On-line* is jargon — it means "operating in direct, concurrent interaction with." It implies that the thing thus interacted with is probably a digital computer. *Intellectual* is intended in the sense of "endowed with intellect or understanding;" *intellect* means simply "power or faculty of knowing." It is not meant to imply any invidious attitude toward any other kind of community than intellectual. *Community* is used to mean a body of people having common organization or interests. Although the phrase presents many opportunities for misinterpretation or noninterpretation, nevertheless, the intended interpretations of its several words blend together to yield precisely the concept I wish to talk about: A body of people working in direct, concurrent interaction with storers and processors of information and, thereby, endowed with the power of knowing.

The on-line intellectual community is a young, but not a new, concept. Particularly, it is not new to the Engineers Joint Council, which has been the focus of much advanced thinking about information systems and networks. The on-line intellectual community is, however, a currently significant concept, for it embraces two of the main themes of current discussions of library and information systems — the computer and the network — and it is setting the direction of much thinking and planning, even though some parts of the concept are not ready for implementation on a large scale in the immediate future. The phrase, "the on-line intellectual community," gained considerable currency, at least within a small group, during the summer of 1965 at Woods Hole, Massachusetts, where Massachusetts Institute of Technology had a planning conference on information transfer experiments, called project INTREX. The book called, "INTREX, A Report of a Planning Conference on Information Transfer Experiments," was published by the M.I.T. Press recently. Chapter IV in the book, is on this same subject and in more detail.

Information Network of the Future

As I listened to Bill Knox this morning mention "$300 million dollars" and say "computer-based information system" several times, my mind leaped ahead to a time when Bill has already been almost wholly successful in moving the mountains that he is moving, when there is indeed a vast computer-based information network. In fact, this network is being dedicated. A measure of Bill's success is provided by the fact that the nation's attention to matters of space technology, and perhaps also to wars in distant countries has been encroached upon considerably by the effort to set up the vast information network for science and technology. The President, on the verge of inaugurating the network, is really concerned about the space program and the war situation, and you can see this concern in his question to the great information machine before him. He says, "What shall we do in order to make sure that we master our own world and establish peace throughout it and complete the conquest of space and, in the name of mankind, remain masters of the universe forever?" The machine says, "Pull out my power cord right away."

When I referred to the computer, I had in mind information processing devices and systems in a variety of applications, but I want to focus attention mainly on on-line interactive information-processing systems. These systems are typified by the Compatible Time-Sharing System of Project MAC at M.I.T. and the Time-Sharing System of the Command Systems Laboratory of the System Development Corporation, or more precisely, the future second or third generations of such systems. When I referred to the network, I had in mind networks of central, regional, and local libraries and networks for the distribution of catalogs, indexes, abstracts, and the like, for example, on magnetic tape. But I want to direct attention to networks of coaxial cable, microwave transmission facilities, and the like, connecting multiple-access computers in various parts of the country, or indeed, the world, into a coherent system spanning disciplines and application areas, and perhaps languages as well as geography.

Since this is a luncheon talk, I shall let wishes have some influence in shaping the concept, but I shall not wholly disconnect the discussion from considerations of technical and economic feasibility. I shall talk about the facilities, functions, and services of the on-line network and then mention a few principles, a few techniques and a few problems. It should not be taken as a statement of a plan or as a revelation. Hopefully, I can paint a picture that will be useful as one of several influences upon our thinking about information systems and networks. Now, many influences on our thinking have the form of extrapolations from existing experience. This one has such elements. Indeed this picture I want to paint is made out of subimages, out of schemata, that one can see operating now in one place or another, in primitive ways. But the thing does not exist yet as a whole, and it may never exist in quite the form in which I shall describe it. The over-all concept may be useful

[1]Consultant to the Director of Research, International Business Machines Corporation.

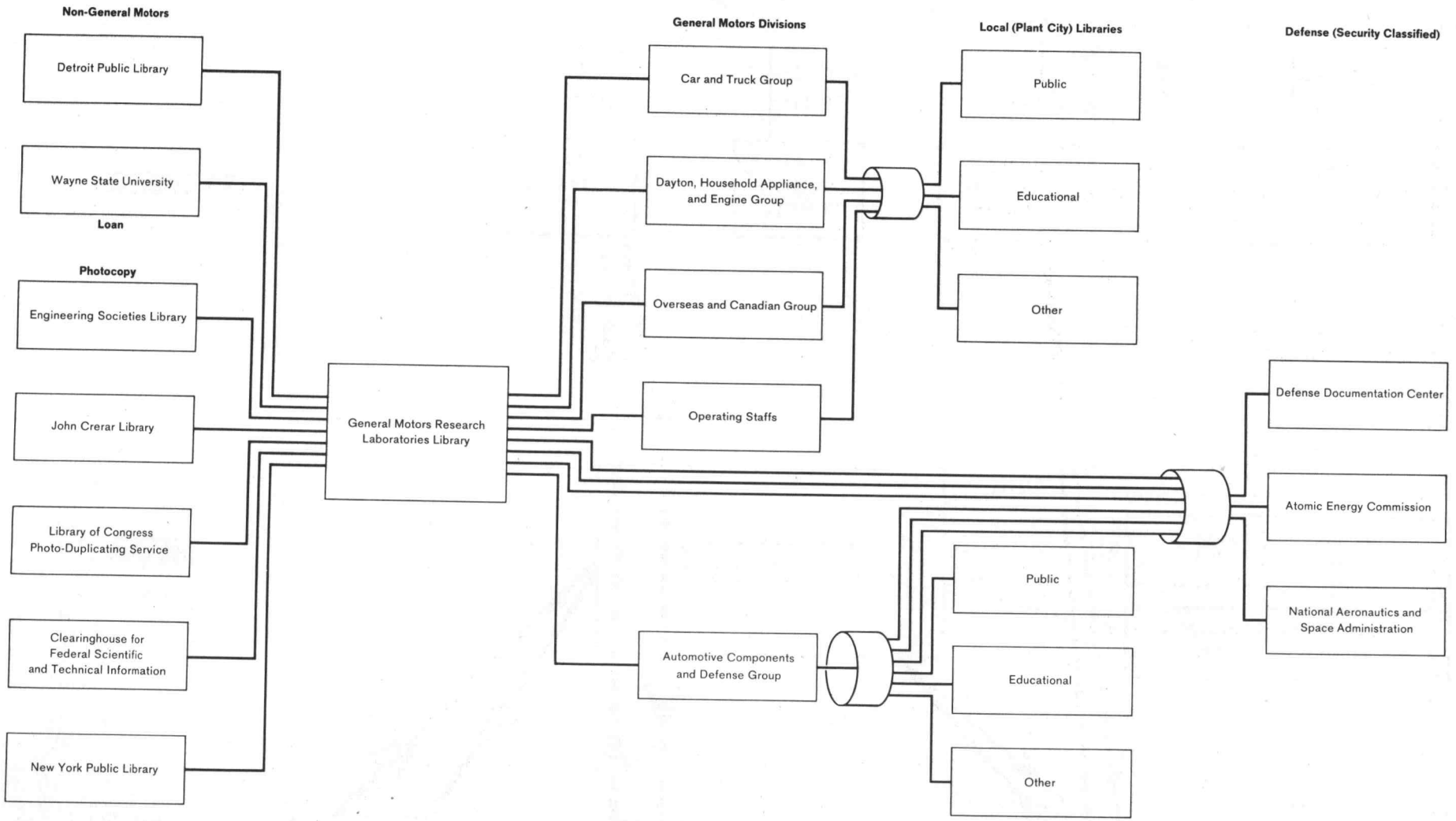

Figure 3. Technical Literature Sources Utilized by General Motors Corporation

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[1]Consultant to the Director of Research, International Business Machines Corporation.

as an attraction, a pulling force, that may influence to some small extent the direction of thinking about the problems that are under discussion at this symposium.

Facilities and Services

Let me start from the user's point of view. The user sits at a console. In my picture, the console is essentially the desk which has become an active thing. It has displays built into it. They are displays of hard copy and of soft copy; displays of alphanumeric strings — letters, characters, words, and the like — and also graphs, diagrams, and pictures. The pictures are either TV-like pictures reproduced with the aid of scanning from pictures in a repository or projections of microimages delivered from the repository to the console. The other displays are driven by electronics, and the information presented exists in computer-processible form in the central or in the local store.

Besides the displays, the user — the man at the desk — has a keyboard and a device like a pencil or a pen (In the current technology, it is usually a "light pen" or a stylus.) with which he can write on the display surface and, if he writes very clearly, or perhaps if he prints, he can be understood by the computer. He uses the latter device also to point to parts of displays presented by the computer; the computer can tell where he points and can make parts of the displayed image follow the pointer.

This potentially powerful and convenient interaction between man and computer stems from early work mainly at M.I.T. and the Lincoln Laboratory. There are in operation at a dozen or more places in the country several systems for computer-aided graphical design, descendants of Ivan Sutherland's "Sketchpad." With the aid of systems such as Sketchpad, you can sketch to the computer, and it records and sharpens up your sketch and "understands" the structure you have conveyed to it.

Besides the pen and display there is, in the idealized console of my mental image, also a keyboard, of course, and perhaps, some mode or function buttons and switches, a headset or loudspeaker, and a microphone. The microphone is not for free, natural-language communication from the user to the computer, but for comments of a simple sort in a constrained language. When you draw a line through something and say *erase*, the computer distinguishes that from your drawing a line through the same thing and saying, *underline* — that level of speech recognition.

Interaction Language

Besides the desk equipped with these devices, and of course, a projector if you work with microimages, there is an interaction language. The essential characteristic of the interaction language is that it is natural enough for the user and formal enough for the computer. The part of the interaction language that flows from the computer to the man is quite different from the part that flows from the man to the computer. The language "spoken" by the computer is largely prerecorded and stored in the computer's memory, in which case it is essentially unconstrained English plus graphics. Some responses are synthesized by the computer. Such a capability, based on advances in computational linguistics, has been demonstrated in primitive forms and is by no means an exclusive feature of science fiction. Indeed, computers now "speak" recorded sounds in practical applications and computer-synthesized sounds in the laboratory, and one can count on auditory as well as visual presentation of the messages that flow from the computer to the user.

The more difficult and more interesting part of interaction language is the part that flows from the user to the computer. This part must be easy for the user to learn and to employ. It must not pose any implicit requirement that the user be skilled in computer programming or knowledgeable about the internal workings of computers, but since programmability is a basic and powerful feature and since elementary programming will find its way into the lives of many members of the on-line intellectual community, the interaction language should include, or provide a bridge to, or at least be compatible with, computer-programming languages.

The man-computer part of the interaction language carries the user's expressions of commands, queries, and declarations. He uses it in calling for the various services afforded by the computer and in controlling and interacting with them. Since his expressions are made partly through keys, buttons, and switches, partly through stylus or light pen, and partly through speech, the interaction-language subsystem must meld those diverse but correlated incoming signals into a unified message stream. Thus interaction language is a large field, full of problems, some of which are unsolved, some almost unformulated. Finding the right structure for, and then achieving an effective implementation of, interaction language will require much work, but I am now assuming that the effort will be successful or, to put us back into the future, that it has been successful.

The next thing the user sees, beyond the console and the interaction language, is the set of services that he calls and with which he interacts.

Services

The retrieval and dissemination service is, in my opinion, the first and foremost of the services. The second is simulation. The simulation that I picture is different enough from conventional computer-program simulation, particularly in making extensive use of dynamic displays, that I shall refer to it by another name — *dynamic modeling*. The dynamic-modeling service facilitates one's expression, one's formulation of ideas, allows one to develop his formulations in a progressive way that involves trial and error and play back his ideas in graphic form and study them to find implications and consequences that otherwise would be hidden.

To appreciate the potential of dynamic modeling, it is almost essential to see examples of it in action. But without this, a word picture may convey some of the force of the idea. In one of Sutherland's (Sketchpad) demonstrations, he drew a bridge — a simple box structure. He drew a support under each end of the bridge, a schematic pillar on which the bridge then rested. In the center, he drew a weight, representing the load on

the bridge. Then he typed to the computer the value of the weight. Th computer memory contained data on the strengths of the linear elements of which the bridge was constructed. (It had been programmed to work on the assumption that the cross-sectional areas were proportional to the lengths.) The displayed picture of the bridge therefore sagged. Then, at Sutherland's command (pressing a button), the computer superimposed upon each element the compression or tension to which it was subjected.

Dynamic modeling in connection with the design of vehicles and structures is so promising and attractive a field that many programs are under way and many examples, more complex and sophisticated but perhaps not fundamentally more dramatic than the one just described, are now available. One involves a ship's hull, sketched by the designer at the console, analyzed and reexpressed in terms of coefficients in a system of equations by the computer, and then displayed from varying points of view under the control of the designer so that he can assess it, appreciate it, or modify it. The modelled ship hull can be towed through a simulated tow tank, the impedance of the water to the motion of the ship can be measured, and the designer can, through a blend of theory and trial and error, progressively improve the performance of his design. Other examples are found in automobile design and in the design of electrical circuits.

The third service is assistance in the generation and editing of text. It facilitates generation, format control, editing, and updating. Nothing in the on-line intellectual community is ever retyped by human hands. After the original typing, the record in the computer's store is modified. When clean copy is required, the computer presents it.

The fourth service is arithmetical and logical assistance. Whenever the user is working with data that are in the system, he can bring already prepared programs to bear upon the data. Thus he can work at arm's length, he need not read every character of the information with which he works if he can define explicitly the procedures that he wishes to apply or if he can specify them by name or function and retrieve them from the library.

Further services include: language processing, for example, analysis of text to discover syntactic ambiguities; data-bank services which will be increasingly important, because more and more information is being collected and recorded in forms that are amenable to arms-length processing; communication among people with reference to stored information, a combination of telephone and television, with a computer in the circuit; assistance in the preparation, debugging, and specialization of computer programs. Specialization is especially important because most of the programs available from the library are written in general forms, and it is often worthwhile to speed them up by retailoring them for the application at hand. Another service is computer-assisted instruction in a wide variety of subjects, including how to use the console and various services available through it.

The foregoing list of services is a fairly complete list of the elements of the intellectual processes in which scientists, engineers, administrators, managers, lawyers, doctors, and several other groups of people engage. Perhaps the list is less complete for humanists than for other members of university communities, less complete for experimental scientists than for theoretical scientists. In the latter case, I should have made it more complete by including assistance in the conduct of experiments, which is a genuine application of on-line information processing, currently the focus of considerable interest.

Library-Document-Information Network

Let me turn, now, to the functions that lie within the realm of the library, the document room, the information system, and the information network.

The whole process of acquiring, distilling, storing, retrieving, disseminating, and using information is facilitated and integrated in the on-line intellectual community. As the research scientist conducts his experimental work through the computer system, monitoring and guiding the probing of nature from his console, he acquires data in computer-processible form. He couples statistical analysis closely to the acquisition of data, sometimes using the results of one minute's experimentation to determine what question to ask in the next. He may come to a point at which data from the library, or from a data bank should be compared with data newly acquired through experimentation and, since both kinds of data are accessible through his console, and not only accessible but also processible with the aid of the same set of analytical programs, he is likely to join the laboratory and library parts of his work more closely together than they are joined in our present-day ways of working.

The theoretical scientist works often with data and often with documents, but his favorite approach involves the dynamic modeling programs referred to in the discussion of services. Some of his models are simply computer-program implementations of conventional mathematical models. Most, however, involve as much logic or decision making as mathematics, and most are too complex or too nonlinear to be treated in the same way as mathematical models that can be represented in a few equations and solved with the aid of paper and pencil. In any event, the theoretician draws some of his models from the library and some from the on-line files of his colleagues, with their permission. Other models he prepares with the aid of modeling and simulation languages. (Even at the present time, there is a profusion of such languages, and a few of them are operating within multiple-access computer systems.) He explores the several models that seem to him to be competitors in the explanation of some range of facts by setting them into operation upon data — data drawn from data banks and files — watching their behavior through graphical displays, and measuring their performance with the aid of specially designed programs that make observations upon the models as they run and even conduct experiments with the models as subjects. The work is often characterized by changes of direction, by modification of one or another of the models to test

out a new idea, and by consultation with colleagues during which two or more scientists, each one in his own office, examine together instances of model behavior that one of them considers to be particularly significant.

Report Preparation and Publication

When the experimenter or the theoretical worker is at a point at which he wishes to prepare a report, he prepares his report at his console. He draws upon data and models and partial representations of results that he has already developed. He assembles those existing pieces and generates new material to create a document. In some respects, the document is similar to today's documents and, in other respects, it is quite different. In its primary form, it consists of computer-processible code and is stored in a secondary memory of the information network. At any time, by any user authorized to have access to it, it can be converted into hard copy — ink on paper — and that is an excellent and much-used form, even in the on-line community.

The main difference between a conventional document and a document in the on-line system is shown by an example: the concept of *figure*. In a print-on-paper document, a figure is a fixed, static thing. It consists perhaps of curved lines against a coordinate framework, or perhaps of diagrams, together with some alphanumeric information. In the on-line network, however, a figure is likely to be dynamic. When the reader interacts with it, pressing a selected button or touching the light pen to a selected spot on the screen, parts of the figure move. If the figure contains a sketch of a device, the device operates. If the figure contains summary statistics, the over-all means break down into component means in response to a query.

Preparation of a report is facilitated by the package of programs for preparing and editing text. The editing programs are used when the document is criticized by colleagues, when it is reviewed by editors, when — if it is a review article or handbook — it is brought up to date. There is, indeed, a great lot of modifying and editing, because the document is available to the invisible colleges of which the author is a member as soon as the author is willing to permit access to it.

In the on-line community, publication will include the placing of data in data banks and models in model collections as well as the placing of documents in journals or libraries. Actually, there will probably be a fusing of the several kinds of repositories and a general integration of the over-all information system, but in the present connection the important point is that, in the on-line network, *publication* has a somewhat expanded meaning. I should mention, by all means, that as much prestige is attached to the publication of highly regarded and widely used computer programs as to the publication of anything else. Footnotes and references are, like figures, potentially active, dynamic data structures. Point at a reference in the proper way, for example, and you will see an abstract of the article cited.

Within the information network, there are several "levels" of publication. Inasmuch as the document is created within the system, a document is published, in a sense, as soon as it is given a tag that permits wide accessibility. In that informally published state, the document accumulates comments, criticisms, and appendages, put there by others who are interested in what it says. The public files of each multiple-access computer system within the information network are guarded by an editorial committee. Acceptance by that committee marks a higher level of publication, one at which the bibliographic citations, the dynamic footnotes, and the like are guaranteed to be in working order. Beyond that level there is formal publication in journals — but note that one form of the journal will be that referred to earlier as the primary form, computer-processible code stored within the network. The motivation for publishing in a journal will be related to the desire for wide dissemination — the information network does not yet extend all over the world — and also to the desire to have one's article well catalogued, abstracted, and reviewed.

That acquisition phase of a library's operation is not the same as for a library associated with the information network as it is for a conventional library of the present day. The computer-processible files of the library are part of the network, and the computer-processible files of the network are part of the library. Data, documents, and models are therefore acquired essentially as they are generated, or at any rate, as soon as they are tagged for access outside the author's immediate circle. Working at consoles within the network are professional cataloguers, indexers, abstracters, organizers, and converters of format. Some of them organize the stores of computer-processible information to facilitate retrieval and to effect dissemination of sets of data, of models, and of documents. Others strive to extract information from the data forms just mentioned and to incorporate it into newer structures designed to support what is sometimes called *information retrieval* in contradistinction to *document retrieval*.[2]

The facilities of the information network permit a much more direct interaction between the professional documentalists and the generators and editors of documents than is possible today. Very close interaction between people with substantive interests and competence in the various fields of knowledge and specialists in the information sciences will be necessary if a truly effective organization of knowledge — an organization both broad and deep and also both coherent and correct — is ever to be achieved. What I am describing is only a concept, but I should like to emphasize the basic importance of reorganizing and restructuring the body of knowledge. Almost surely, natural language is not the preferred form, and neither is natural language intermixed with expressions in one or another language of mathematics or logic. Other ways of organizing and structuring information are being explored, and it seems likely that formalisms will be developed that will facilitate distillation and crystallization of knowledge, that will permit more compact storage, that will be amenable to processing, and that will be more expressive than

[2]It is unfortunate that "information" is used sometimes in a generic sense to cover all forms and types and, at other times, as a lower-echelon heading, but so it is.

the natural languages are. The dream is rather far from realization, but I think it is a realizable dream, and a very attractive one too.

Announcement and Dissemination

The on-line intellectual community is an excellent testing ground for systems of selective information dissemination. Several good systems have been tested, and the best of them are in fairly widespread use within the network. When a user sits down at his desk (console) in the morning, he finds a "message of the day." It is tailored to his special interests, which of course are known by the system. The message of the day tells him briefly what has happened within the network that is likely to affect him.The first part of the message concerns changes in operating procedure and in the set of services available. The second part concerns acquisitions of information. The message is in a sense a combination of a news bulletin and an index: It contains pointers which, when activated by a user, lead to additional information. With their aid, he can explore in depth any items that prove to be of particular interest. The announcement of library acquisitions and the dissemination of abstracts and documents are coupled to the message of the day. At any time, however, a user can request to see the announcements or to receive his dissemination allotment, and many users prefer this compromise between retrieval and dissemination to unsolicited dissemination.

The retrieval function is absolutely fundamental. The language through which retrieval specifications are formulated is the interaction language itself. It permits convenient expression of Boolean queries and questions in higher order formal languages. If what the user specifies is a reasonable prescription, the retrieval system sets to work to deliver the requested information, and it usually provides rapid service. If the prescription is not reasonable, the retrieval system enters negotiation with the user and helps him state his description of what he wants through conversational interaction. The information network extends into the array of national resources, and perhaps international resources, discussed by Bill Knox.

Interrogating the System

The picture I am trying to paint assumes that Bill and his colleagues in the Office of Science and Technology and on the Committee on Scientific and Technical Information have been successful, that the national and international informational resources are well organized and effective. In the interest of concreteness, however, I shall use the present-day names of some of the agencies as I try to describe briefly the kinds of service available to a user at his console. The user interrogates the Science Information Exchange to find out who is working, under government support, on a particular problem of immediate interest to him. He interrogates The National Referral Center to find out who holds documentary information about the problem. The National Referral Center may direct him to the appropriate Scientific and Technical Information Evaluation Center, and he may communicate through the network with an expert there who may agree to work up a bibliography and a technical summary, provided, of course, that a Governmental agency that supports one or the other of them, or preferably both, will pay the bill. To get actual documents and data, the user interrogates the Clearinghouse for Federal Scientific and Technical Information, which starts immediately to fulfill his requests and bill him through the network, but the user diverts his inquiry to the Defense Documentation Center and the information facilities of the Atomic Energy Commission and the National Aeronautical and Space Administration, with which his institution has research contracts. Actually, behind the facade of agency names, there is (in this conceptual picture, but not yet in actuality) just one large computer-based information system, but it keeps books and respects authorizations in such a way as to maintain the illusion of departmental organization.

Question Answering

I am not sure whether or not I should include a question-answering service within my picture of the information network. I am both greatly fascinated by the problem and greatly impressed by its difficulty. The information network that I have described will probably provide a limited question-answering service. It will be based on ways of representing information quite different from those we use now.

A basic technique for question answering was demonstrated several years ago — first, I believe, by Fisher Black, but also by several others. The information on the basis of which questions are to be answered is represented in the language of a predicate calculus. Information in such a form is processible by computer, and the computer can, with the aid of appropriate programs, make deductive inferences from the information. Questions are posed as tentative assertions in the same formalism. In the case of yes-no questions, the computer determines whether the question statement or its negative can be deduced from the information base. If the assertion can be deduced, the answer is "yes." If the negative of the assertion can be deduced, the answer is "no." If neither can be deduced, the answer is, "I don't know." Questions other than yes-no ones involve variables. The procedure for answering those questions is more complicated, but in fact the computer comes forth with lists of values corresponding to the variables or with "I don't know."

Thus far, question-answering systems have encountered two difficulties. First, it is difficult to program a computer to translate from natural language into the formalism of predicate calculus — difficult even in instances in which the translation is theoretically possible. Second, it takes a fantastic amount of computing to answer even simple questions.

In one of his demonstrations, Fisher Black solved a problem, called the "Airport Problem," posed several years earlier by John McCarthy. I shall state it simply in a rough English approximation to the predicate calculus of the information base and of the question:

> I am at home. My car is in the garage. The garage is at what I call "my home." I can walk from any place I

call "at home" to any other place I call "at home." The airport is in the same county as my home. I can drive from any place in the country to any other place in the county. I want to go to the airport. What do I do?

After spinning its wheels for an embarrassingly long time, the computer produced the answer:

Walk to the garage. Drive to the airport.

That performance is trivial, and yet it is very fundamental. It is fundamental because the computer is not as greatly handicapped as a person would be if there is a large amount of irrelevant information in the information base. The Airport Problem is essentially the basic problem of logistics: With such and such resources, with such and such capabilities, and with such and such an intention, can I succeed? If so, how? If not, why not?

Communication and Interaction

Again concerning the function of communication among people with reference to, and in interaction with, stored information, present-day time-sharing systems are already providing a glimpse of how that function will be employed and how important it will be. Typically ones, closest intellectual colleagues are not geographically his closest associates. In science, technology, administration, and several other fields, they are likely to be remote. Through information networks, even through teleprocessing in a system with a single central computer, geographically distributed colleagues can work together in interaction with stored information using dynamic interaction with models and data, and collaborate as effectively as if they were in a face-to-face conference. I think that that statement is not a severe exaggeration.

Earlier I mentioned "arm's length interaction" with information. As a brief illustration, suppose that the user is trying to determine which, of all the harbors in the world, a particular vessel can enter and reach a dock without running aground. To answer that question, he has to do a considerable amount of calculation. The calculation must take into account the shape and depth of the vessel and also data about the conformations of the bottoms of harbors. If one thinks of executing this task with pencil and paper, he must solve, first, a subordinate problem: how many clerks will it require to carry through the calculation in the time available. Working at a console in the information network, however, one can think and experiment until he figures out how to solve the problem for the given vessel and one harbor, and then he can simulate the passage of the vessel through the harbor to the dock so that he can discover any visible flaws in the method. And then he can command the computer to apply the same procedure to the data for all the other harbors in the data base. Note that the "data base" is an essential part of the facility for solving this problem. Note, also, that it would not be helpful to have the data base if all you could get from it were a printout of all the data. The essential thing is to connect the several required services together to integrate them into a unified or coherent system. With such a system, one can solve his problems without having to take in through his eyes and process with his brain every element of informational detail that is required in the solution. The need for such a facility, for such a system, recurs over and over again in business, in military, and in academic thinking.

There are many more functions, but perhaps I have said enough to suggest to you the nature of the over-all picture. If you project yourself into that picture, you are working at your desk (console) with information that you select, and the processing of which you control, through an interaction language. The information is stored in a system of memories associated with a network of computers, communication links, and display and control devices. Your purpose in interacting with the information is to solve a problem, to come to a decision, to explore an idea, to formulate a question, or something of that general nature. Presumably, you are expert at defining your purpose, pointing to your goal, dreaming up a plausible hypothesis, and telling whether, in the course of your effort, you are on a promising track. Almost surely you are not very good at carrying through the detailed clerical operations that are involved. The computers of the network are very good at that, however, and their short suits are your long ones. You and the computer network complement each other neatly and, working in close interaction, you accomplish your purposes with efficiency and dispatch.

That is, at least roughly, the concept. I have been careful not to advertise it as a goal near at hand, as a thing achievable in the near future. It is amazing to me how many of the elements of the concept are demonstrable now. My final endeavor is to set forth a few principles that are relevant to information networks and to the concept of the on-line intellectual community.

Statement of Principles

The first principle deals with interaction, with the direct "on-lineness" of man-computer interaction. The principle is that it is truly essential to receive service "within the thought cycle." That is to say, it is important not only to get what you ask for but to get it while you are still thinking about the problem, and not tomorrow or the next day. Immediate delivery of the product is the essence of retrieval. Immediacy is especially important in constructive thinking. Constructive thinking can be analyzed into two elements. Man is very good in handling one of the elements. He is very good at guidelines, at formulation, at creating hypotheses, at playing it by ear, setting goals, and at evaluating success in meeting them. In the jargon, these functions are called "heuristic." But man is, as now appears evident to almost everyone, a slow and inaccurate executor of predesigned, preprepared procedures. This function is sometimes called "algorithmic." The great success of computers in science and industry has been based mainly on the fact that they are extremely fast and accurate in following prepared procedures, in executing algorithms.

Most constructive thought involves a playing, back and forth, between the heuristic and the algorithmic functions. The interplay cannot be effective if the time required is a day or even an hour. The algorithmic response should arrive within seconds. Indeed it is some-

times frustrating if it takes even seconds.

The second principle is that of processing information at arms length. I shall give one more argument for its importance. People read slowly. If we define a sub-field in such a way as to divide the over-all field of science and technology into about a thousand parts — of which a typical one might be, for example, oceanography — then a man reading the literature of a sub-field as though it were a novel, eight hours a day, would finish reading the literature on which he started at a time when the literature had just doubled. It would take him about ten years to read what there was when he started. When he finished, there would be another ten years' worth to start on. After that, of course, he would be in an even worse situation, but we can readily see that a man cannot read everything that is relevant to his work. We have to develop ways of processing more of the information we use in intellectual work, ways that are at least roughly comparable to those used by business firms in handling their payrolls and inventories. This may not be a wholly attractive thought, but I think it is a crucial one. We need to progress from the intimate connection that a laborer has with his material to the arms-length connection that an executive has with his.

The third principle, which is, I think, the most important one, has to do with cooperation among people. Most large tasks are too large for one man. When several or many men are required to accomplish a goal, it is essential to organize the effort so that the individual contributions fit together. Unfortunately, it seems to be even more difficult to achieve coherent and cooperative interaction in intellectual work than it is in clerical and physical labor. There is, however, at least a reasonable hope that on-line information networks will facilitate cooperative interaction in intellectual endeavors.

In the universities and research organizations that have been accumulating the initial experience with on-line multiple-access systems, most of the effort and most of the interest have been focused upon the problem of improving the effectiveness of individual users. It is now quite evident that close interaction with a well-programmed computer can do great things for the thinking of the individual. As more and more people have become participants in on-line information processing, it has slowly dawned upon observers that the facilitory effect may be even greater for group thinking, for the intellectual process of the community, than for the individual members considered one at a time. It is beginning to appear, indeed, that multiple access to an interactive information-processing system is a precondition for coherent intellectual work involving several or many people. In rough analogy, a multiple-access computer system provides a nervous system for a local community and a network of such systems provides a nervous system for a geographically distributed community.

There are two main reasons, why the social implications of multiple-access computers and information nets are starting to become evident only after two or three years of experience with time-shared computers. The first is simply that arrangements for individual access were made before arrangements for access by pairs or teams of people, and that there has been, as yet, very little experience with true information networks. The other reason is that most of the "software base," the collection of programs and data available to users, is generated by users in the course of their day-to-day work. Only after a fairly long period of operation does a multiple-access computer system present to its users a comprehensive set of intellectual tools.

It is interesting to project this idea of development through use into the field of documentation. At the present time, most cataloguing, indexing, and abstracting is done by professional documentalists who understand thoroughly what it takes to make a good catalog, a good index, and a good abstract. However, few documentalists are deeply immersed in generating the literature of physics or sociology or marine engineering. There is always the problem, therefore, of injecting into the bibliographic apparatus the necessary deep understanding of technical substance. Obviously, the problem can be solved only through close interaction between substantive competence and competence in documentation and information science. Ideally, that interaction would take place in the brain of one individual, who would understand both fields thoroughly. But it is unrealistic to try to solve the whole problem with that approach. On-line information networks introduce the possibility of achieving very close interaction between the substantive scientist or engineer and the documentation expert. As suggested earlier, that interaction can take place during the actual preparation of a report and continue on through the process of editing, publishing, and incorporating into the body of knowledge. The interaction does not have to be mainly a matter of conversation; it does not have to waste much time of either party. Most of the contributions of each party can be developed independently. The crucial things made possible through on-line interaction are the occasional brief discussions in the interest of clarification of specific questions and the joint work sessions in which the independent contributions are fused together to produce the final documentation. Perhaps I should mention explicitly that the work of cataloguing, indexing, and abstracting will be greatly facilitated by preliminary work done by programs operating routinely within the system. These will check citations, produce indexes and abstracts, and so on, for the author and documentalist to use as raw materials. Also important contributions to the apparatus of bibliographic control will accumulate as by-products of use of the system. Users will make comments, and, after editorial acceptance and authorization, some of the comments will be appended to published items. Simply by retrieving and using data or models or documents, people will generate "trails" through the information base. These trails will bring about, at long last, a realization of Vannevar Bush's "MEMEX." Proprietary users may choose to erase their trails, but academic users will probably be willing to offer them as a contribution to the public domain. Perhaps an engineer will find himself thinking, "I want to see what so-and-so has been doing. He has been turning out better ideas this last year than I have."

In conclusion, I should like to touch again upon a few of the points that I have mentioned or discussed. Dynamic modeling seems extremely promising. It introduces a whole new dimension into the process of thinking. It promises to let you see the implications and consequences of your ideas — indeed, to let you see whether you have yet formulated a complete idea, capable of "running" in the computer and displaying its behavior to you.

"Pointers" in the text seem to me to have a different level of importance. It is merely a matter of convenience, and not in and of itself a breakthrough, to be able to explore an idea further, in a selected direction, by touching the appropriate one of several buttons or several patches of light on a display. On the other hand, I think that a sufficiently large set of mere conveniences can constitute a major factor in the intellectual process, and I am choosing pointers in the text as a representative of a set of conveniences, which I should like to see developed and polished and made available for widespread use. Recently I spent considerable time on a list of fifteen references for a paper that was overdue and absolutely had to be put into the mail. Actually, I had to drop three of them because I could not get my hands on the complete citations; I had read the articles, but I had not taken good notes. How helpful it would have been to me then to have a console in an information network, to point to a citation in a bibliography and see, immediately, the list of references in the article cited, and then to point to one of those and see the article itself. With such an arrangement, it would not have been so hard to find the final page number of an article for which I had all the other bibliographic information.

Passage retrieval is a compromise between document retrieval and question answering. It is essentially impossible to describe the contents of a book with three or four terms or even with a dozen descriptors. With no more sophisticated apparatus, however, it is possible to describe the contents of a short passage, a paragraph for example, fairly well. A straightforward path for progress in the information-retrieval subsystem, therefore, is to progress from document retrieval to passage retrieval.

Question answering seems so desirable to me that I do not want to let my mention of passage retrieval divert attention from the idea of question-answering systems. Research on such systems may be expected to lead to new ways of structuring and organizing information and perhaps also to a desirable formalization of language for science and technology, increasing expressive power without decreasing convenience.

Problem Areas

Four of the problems that stand in the way of realization of the on-line intellectual community are: 1) getting text into computer-processible form, 2) providing wide-band switchable communication channels, 3) providing economical yet adequate graphical displays and, 4) developing a good interaction language.

The best way to get text into computer-processible form is to generate it in that form and keep it in that form. There is no technical obstacle in the way of doing that right now. To convert from print on paper to computer-processible form requires either a human agency or automatic character readers or page readers. Human capabilities are not well matched to the task. Automatic converters are available for limited applications and under development for general applications.

At the present time, wide-band switchable communication channels are not widely available through common carriers, and the available narrower band or non-switchable channels place undesirable restrictions upon the flexibility and capability of information networks. It seems desirable to set up, in an experimental way and at an early date, a pilot network with wide-band switchable channels.

Whereas computer output used to be mainly in the form of print-outs, computers are now generating, in increasing numbers, graphs, diagrams, and pictures. To produce a dynamic graphical display requires, at the present time, a considerable amount of computing and data transmission. An impressive effort is underway to make dynamic display simple, rugged, convenient, and affordable — to place it on the desks of many people.

And finally, concerning interaction language: the essential problem is to find a formalizable subset of natural language that will seem natural to people and be easy to use as well as to stay within the limits of, and be capable of subsuming and being translated into, most of the special-purpose languages that are intrinsic to time-sharing supervisory programs, problem-oriented compilers, and the various service packages that I have discussed.

Pilot Studies and System Component Evaluation

BY NORMAN E. COTTRELL[1]
and
CAROLYN M. FLANAGAN[2]

We should make a clear and careful distinction between what we can do now, and are doing now, and what may be done eventually by an Engineering Information System. Three stages illustrate this concept:

1) We can now operate a system to handle accurately engineering literature.

2) We expect to develop plans shortly directed toward effective handling of engineering data.

3) Eventually we should anticipate direct on-line, real-time access and interaction between engineers, employing graphic representations and complex data banks of engineering tables as described earlier in the symposium by Professor Rubinoff and Dr. Licklider.

The symposium papers have indeed covered a broad spectrum concerning engineering information handling; ranging from highly advanced concepts, broad expressions of comprehensive federal government planning, and areas of problem definition and needs, to technical library operation.

Large expenditures are being made for dissemination of technical information through conventional publication means, both primary and secondary. Emphasis has been toward the production side rather than toward determination of what specific information applies to particular problems, or what may be considered important and unimportant. There is a tendency to concentrate on new and innovational areas of technical development, whereas each new development can well create the need for reevaluation of adjacent materials.

Information analysis centers have been a significant development aimed directly at this problem area of technical information utilization and effectiveness, but even in these areas, usage to date appears surprisingly low.

While large expenditures have been and are continuing to be made in experimental and theoretical research in information systems, all too little is directed toward vital applied research, and even less to operational testing in real-life environments.

It is within this brief background that we direct your attention to the joint pilot programs of the Engineering Index (EI) and the American Society for Metals (ASM). This joint program provides important and far-reaching progress toward the development of an overall Engineering Information Center and Network. Significantly, these two activities represent, in the Engineering Index a central collection or store of engineering information, and in American Society for Metals an individual technical society devoted to specialized engineering information handling. The relationship and interaction permit an operational working model in a real-life environment and the development and testing of information system components within the framework of the Engineers Joint Council program.

Principles of the ASM Mark II System

Let us now turn our attention to advanced work by one of the pioneers in the field that has made a significant contribution to our progress. I am referring to the American Society for Metals and the four phases of their development to this point. ASM, whose sole function is to disseminate technical information, concluded wisely and imaginatively in 1955 that it should consider the implications of mechanized information handling and the potentially important impact this would have on their traditional function of technical information dissemination. Phase 1 was a feasibility study concluded in 1960. This led to the recommendation for phase 2, the design and operation of an experimental system. Phase 2 was carried out with considerable assistance from the National Science Foundation and in in conjunction with Western Reserve University in Cleveland. The total expenditure, shared approximately 50% each by ASM and the National Science Foundation, was approximately $2,000,000. Phases 3 and 4 commenced in 1964. Phase 3, still in progress, consists of the redesign of the Mark I System to the Mark II System. Phase 4 being carried on concurrently, is a program of extensive applied research into user needs.

The Engineering Index, whose traditional past needs no introduction nor comment here, came to the conclusion in 1964 that it should move toward the development of an integrated information system to complement its traditional activities. Commencing in 1964, with the assistance of Battelle Memorial Institute, the Engineering Index started independent development of such an integrated information system.

International Business Machines, quite independently of the other two activities, developed the concept of an advanced information system directed at utilization of modestly priced computer equipment, and designed to accomplish the joint advantages of serial and inverted term file organization.

It was possible in late 1964 to bring together these four separate operational components — the American Society for Metals, Engineering Index, Battelle Memorial Institute and IBM Corporation — into a common effort toward development of the EJC pilot system. To realize the major advantages of joint development, each

[1]Director, Documentation Service, American Society for Metals.
[2]General Manager, Engineering Index.

organization made changes in its own detailed approach to the program. It is therefore the convergence of these four activities that comprises the basic background of the pilot system development which is the subject of this paper.

We acknowledge the support that the National Science Foundation has given to the ASM Mark I and Mark II system development and the continuing support by NSF to Engineering Index. In addition, the Atomic Energy Commission and the National Academy of Science Foundation has given to the ASM Mark I and ences contributed to the support of the ASM project and the Engineering Foundation contributed to the support of the Engineering Index.

Thus, briefly, the goals established by EJC in 1962, the know-how and operational experience gained by ASM and the overall experience and background of Engineering Index in handling technical information — with considerable help of IBM and Battelle — came together. The convergence of these forces and the output of these forces will be discussed next.

"System," as referred to in this paper, represents the total process used in all of the steps, either manual, intellectual, machine or combined aspects in the process of handling information in the total system. The components, therefore, that will be discussed involve those that are primarily human or intellectual such as quality control, selection, abstracting, indexing; the input of retrieval programs, and the interaction of user feedback to the system. The thesaurus as a component may be considered a combined aspect of both intellectual and machine import. Elements that may be considered in the machine system aspect include the input programs, computer programs, the central logic of the computer system which consists primarily of the "Combined File System" as developed by IBM and modified to suit EJC requirements, a publishing system, retrieval computer programs, user feedback programs, and direct computer test sets.

In the area of quality control, it should be clearly and strongly emphasized that we are seeking the highest possible level of quality. We are not content with less than qualified engineers or scientists doing the all-important task of analysis of information and precise assignment of the important vocabulary and indexing control.

Selection is an element that again requires the utmost precision in carefully delineating what you are going to include and what you are not going to include in the system. It must be sufficiently flexible to change as new materials or new areas of technology develop and come into operation.

Abstracts must be informative and this is recognized in the abstracting policies of the ASM program. The objective is to provide as much information as possible to permit the reader to determine whether or not the original article should be obtained. A training course conducted by Battelle Memorial Institute, sponsored by EJC, has developed an effective course in abstracting and the following step of indexing. This course represents a significant accomplishment and provides a means by which an organization can start from scratch to move effectively into a production operation in this field.

Indexing is so closely associated with abstracting that once the analyst pursuing the technical information has mastered the content of the article, it is relatively simple to assign the index terms and devices which serve to identify these terms in their proper relationships. Increasing use, however, of good indexes tends to make the indexing function more clearly identifiable as a separate function of the system. Definitive large-scale operational tests are now under design and will be carried out during the next several months. These tests will be carried out in an operational environment against the Mark I system developed at the American Society for Metals. Results of these tests will be made available to all EJC member societies and to others who should be interested.

Natural language, vocabulary control, and therefore the hierarchical thesaurus constitute perhaps the single most important component in the overall system. Because the thesaurus provides to both the user of the system and the information analysts who are placing information into the system a common logical organization of technical terminology and their inter-relationships, the ability of these two groups of people to consistently and accurately perform their respective functions is much improved. Therefore, the economic operational aspects of the system are improved because there is less need for human intervention and consequently a much higher degree of automatic processing. Characteristics of the internally machine stored hierarchical thesaurus offer another significant advantage in that it makes a near optimum use of computer capability because it sensibly provides a logical internal network. It also provides for simplifying the role of the information analyst as well as that of the user of the system. The user is able to approach the system in everyday engineering language, and the machine then assumes the responsibility and will consistently follow the logical network paths to select the desired information.

The *Thesaurus of Engineering Terms* published by EJC is in its first edition. Plans are now under way and funds have been appropriated for a second revised edition. A metallurgical subset of the EJC Thesaurus has been prepared by the American Society for Metals and it will be published within the next several months. This provides a more specific language particularly for metallurgists and materials specialists.

Computer programs: Programs are under development by Engineering Index with the help of consultant staff and the IBM organization. These are carefully coordinated to serve the combined purpose of the other groups who are working on the pilot project. They are further designed in a generalized nature to apply to the full range of engineering information problems. These programs have been completed and are in operation.

The Combined File System is the name which has been applied by IBM to the central logic of the computer system. These programs are now undergoing major modifications to adapt them to the EJC conceptual requirements. These programs are in existence and are being used by a number of information activities. The

final modifications, it is anticipated, will be made within the next three to four months and in their final stages it is estimated will represent an extremely powerful information handling system component in that it combines the best features of a serial file with those of an inverted term or subject file of information.

The next component of the system is the publishing system. These programs are designed to take the index terms as developed by the information analysts and from these generate a publication index which incorporates both author index and subject arranged alphabetically with ample cross-references to show in the best integrated fashion the proper content of the related publication. This component of the system has been developed primarily by the American Society for Metals with the assistance of IBM and EI. These programs are completed and are in operation.

The information retrieval components of the system represent a series of interface programs adapting the EJC system of links and roles to the combined file system logic, as well as interface programs interconnecting the ASM Mark I system. These programs will be undergoing final design and test within the next several months. Continuing operational tests between the Mark I ASM system and the EJC system employing the EJC links and roles will provide large-scale definitive operational testing of these components in a real-life operational environment. The proceedings and results of these tests will be made available to all of the engineering societies and others who have specific interest in this all-important problem.

A series of programs, now in a general planning phase and as yet not completely defined, have to do with the re-entry into the system of critical user feedback of evaluation of material received. This is recognized as a required component of the system and is under consideration.

The same general comment may be made concerning programs that are strictly in the planning stage at this time, designed to permit testing of direct user inquiry to the system and real time response capabilities. The type of equipment presently being employed will require in its conceptual stages simulation of real time aspects of operation. Nevertheless this is recognized as a vital potential requirement which will receive the utmost care and study from operational and economic aspects.

In summary, specific components of the pilot programs are in existence and are being currently applied. Their logical expansion and further refinement will provide the initial required components to make up an integrated information system.

Design Capabilities: Important design requirements of the system are that it shall have the capability of handling document retrieval or abstracts and indexes as well as the logical capability to operate upon tabular and numerical information.

As was mentioned earlier, we are dealing in natural language, and therefore, the system is designed to provide the most useful capability for the individual engineer or scientist. Because of the use of natural language, the system can provide direct access on the part of the user to the system without going through an intermediary. This of course, would be mandatory if we are to talk of the eventual real-time, on-line, direct inquiry to the system.

An additional important design characteristic of the system is that it permits multiple access. Due to the fact that the internal logic organization is built on a hierarchical stored thesaurus, one might gain access to the same bit of information from different or multiple sources. The internal logic network would unerringly and systematically channel this through the logic pattern to obtain the same information even though it might be obtained through many different routes.

Equally important as a design capability objective is that of optimum indexing consistency. What is meant is that different people over different periods of time will be operating with a controlled and understandable language so that the same technical information will receive the same treatment from all people. While this may appear rather simple and fundamental, it is actually extremely difficult to achieve. It is, therefore, with real enthusiasm that we can report that the systems design characteristics call for a high order of performance in this all-important area.

The very nature and structure of the language and control vocabulary offer real hope of interdisciplinary communication, perhaps in a direct fashion and at the very least an intercommunication through some translation device.

Furthermore, design capabilities permit application of the system on a moderately priced computer. There are many systems operating today on machines in the rental magnitude from $30,000 to $50,000 per month. The initial pilot programs we are presently discussing are operating on tape equipment, in the rental magnitude of $6,000 to $8,000 per month. It is felt in this way that the system may represent maximum usefulness to the largest number of engineering and scientific organizations.

Project CADRE —

A Study in Progress at Engineering Index

The Engineering Index Annual Volume and Monthly abstract Bulletin are familiar items in most technical libraries. A study was made about two years ago with a view to improving these services, taking advantage of new techniques, and following broad concepts advocated by the Engineers Joint Council, so that the engineering and scientific community could be better served. As a result of this study, Engineering Index embarked on a program aiming to provide both an improved bulletin for manual search and a central machine search capability, to include selective dissemination of current information as well as retrospective search.

The system is called CADRE, for Current Awareness and Document Retrieval for Engineers. These combined services constitute an important step toward the long-range goal of establishing an Engineering Information Center (1) at the United Engineering Center in New

York. It is envisioned that this center will be linked to other information centers through an Information Network (2).

As an initial step toward this goal, a pilot study is under way in the electrical-electronics field and in the plastics field. The work sheet filled out by the abstracter-indexer serves as the basis for entries both in the Bulletin and in the deep index involving links and the EJC roles for machine search. Eventually, it is planned to extend the service to the other engineering disciplines.

Some indexer-abstracter personnel were recruited from the regular Engineering Index professional staff and others from outside. All were given training on an indexing structure, for the most part new to them, which includes the coordinate indexing principle and the system of roles sponsored by EJC. Training and drill over a six month period was supplied by members of the staff of Battelle Memorial Institute, who were currently giving the training course in coordinate indexing, sponsored by Engineers Joint Council. Considerable further training beyond the content of this course was required.

The Institute of Electrical and Electronic Engineers (IEEE) and the Society of Plastic Engineers (SPE) have set up liaison committees to guide Engineering Index in several ways:

(1) Selection of additional journals to be covered.
(2) Review of rules for selection of articles within journals.
(3) Technical consulting aid in structuring of thesaurus.
(4) Feedback for constant evaluation and improvements in the system.

At the early stages of the development of CADRE, Engineering Index considered using existing computer programs for building the index and thesaurus validation, as well as search and index printout steps, as an alternative to the development of complete computer programs at Engineering Index. Existing computer programs either required more sophisticated computer configurations than those originally available to Engineering Index (IBM 1401-8K-4 Tape), or failed to include some of the steps envisioned for the system.

As pointed out earlier in this paper, a conference was held involving Engineering Index, ASM, IBM, EJC and NSF observers. As a result of this conference the Combined File Search (CFS) system developed by IBM was accepted as a basic computer program "package," with the view of adding to it additional programs needed to meet the requirements of the CADRE and ASM Mark II system. These additional programming responsibilities were assigned to EI, ASM and IBM. The initial computer programs dealing with building the index and publishing the bulletin were completed on schedule. An index with machine search capability has been built by EI during 1965. Both EI and ASM have published abstract bulletins with computer-produced indexes during 1965.

The Bulletin: With a separate bulletin for each of the two disciplines in the pilot study, Engineering Index is offering for the first time a selectivity based on discipline.

The bulletin lists all abstracts by categories, defined so as to divide the field into segments of interest. Within a given category, abstracts are listed in order of accession number. The content of a given article could justify its inclusion in more than one category, but practical considerations do not allow its appearing more than once per journal issue. It follows that the perusal of the articles in a given category will not necessarily catch all the articles pertaining to that category. Thus the category listings are for browsing only, and anyone wishing exhaustive coverage of a given topic in a particular issue must use the subject index. (This same format is followed in the ASM Review of Metal Literature.)

The subject index is prepared by computer and each normal entry under a subject heading comprises a Notation of Content (NOC) and the respective document number. The NOC is a display in title format and may actually be the title, if the latter truly indicates the gist of the article from an engineering point of view.

In the Index Section, under certain subject headings are "see" or "see also" references, which refer to another subject heading, but not directly to a document number and NOC. If the reader consults the subject heading referred to, he will find at least one normal document posting with NOC.

The "see" or "see also" entries represent access points too important to be neglected, but not important enough to warrant the space required for a normal entry. As will be explained later, these indirect access points are all generated by the computer from entries in the thesaurus.

It is anticipated that certain new problems will arise when the system is extended to cover all engineering disciplines. For example, large libraries will want the entire service with a single index. Other subscribers will want only the coverage of individual disciplines. Engineering Index plans to have sufficient flexibility in technical output and in pricing schedules to satisfy all types of subscriptions, including tapes of the machine searchable indexes.

A solution is being worked out so that articles logically assignable to more than one discipline, and hence to more than one bulletin, can be given multiple coverage. Thus a subscriber to a given discipline will be assured of bibliographic access to articles bearing on that discipline, even when the articles are primarily concerned with a different discipline. Duplicate coverage would be suppressed in merged indexes covering the entire service.

The Thesaurus: The *Thesaurus of Engineering Terms,* published by the Engineers Joint Council in 1964, serves as the starting point for the Engineering Index thesaurus (not published), just as for the ASM thesaurus. The Engineering Index thesaurus requires somewhat greater specificity than the EJC thesaurus, but is limited mainly to terms used in the two disciplines being studied in the CADRE project. In common with the EJC thesaurus and others, the Engineering Index thesaurus comprises an alphabetical array of main terms, with scope notes and net-of-kin terms shown under them indented and preceded by a cross reference

code (CRC) to show what the kinship is. The main term together with its scope note and indented terms comprises a set. Examples of such CRC's in the Engineering Index thesaurus are BT (broader term), NT (narrower term), RT (related term), USE (substitute), CO (coordinate). The first three codes help guide the user to the best choice of terms where he has a choice. The last two codes force the indexer (or in the case of USE, direct the computer) to substitute the term or coordinate the terms for the main term of the set.

Terms which call for a substitution of one or more terms to represent the concept in indexing are called subterms (terms requiring a substitution). Other terms are called entry terms, since they allow document postings under them in the index. The Engineering Index thesaurus contains another class of terms, trial subterms, which require substitutions but also allow direct postings. Thus if it is decided later to promote such a term to an entry term, the previous postings under it are already on the record, and no re-indexing is needed. Likewise, if it is decided to demote the term to a permanent subterm, the previous postings under the substituted term or terms are already on the record, and no re-indexing is needed.

The thesaurus maintenance system allows changes to be made in the indented terms in a set without deleting an entire set. Only the main term and the indented term need be added or deleted. Furthermore, if the indexer adds a term to a set, the computer generates the reciprocal of this relation (where the main term and indented term change places). For example, if the following is added:

INFRARED RADIATION
BT ELECTROMAGNETIC WAVES

then the reciprocal relation is generated by computer:

ELECTROMAGNETIC WAVES
NT INFRARED RADIATION

Similarly if an indexer deletes the BT (broader term) above, the reciprocal NT (narrower term) relation below will also be deleted.

A subset of this thesaurus tape is generated on another tape so that the computer can use it to carry out its three jobs, namely:

(1) It validates all terms used in the machine-searchable index and in published subject headings, thus alerting indexers to terms that are invalid or misspelled.

(2) It substitutes a single preferred term following the cross reference code, USE.

(3) It generates a "see" or "see also" reference in the published bulletin provided both of the following conditions prevail:

(a) The indexer has entered a term, such as DEMODULATORS, on the work sheet, thus generating a normal entry (NOC and document number) in the published bulletin.

(b) The respective term, such as DEMODULATORS, in the thesaurus has an indented cross reference term, BT* DETECTORS, the asterisk being the key character.

If the two above conditions prevail, the computer scans the thesaurus set under DEMODULATORS and finds an asterisk following the cross reference code, BT. It then generates a cross reference in the bulletin as follows:

DETECTORS see DEMODULATORS

If normal entries are also found under DETECTORS, the SEE would become SEE ALSO.

Since the thesaurus is at the heart of the CADRE system, it is very important to maintain its structure at a high level. To aid in this endeavor, the liaison committees set up by both cooperating professional societies have been very helpful.

Relations With Sponsoring Societies: The liaison committees established by the sponsoring societies have already been described. It is useful to look at the CADRE program as an extension of the editorial and publishing programs of the sponsoring societies. This relationship should manifest itself in various ways.

(1) With Engineering Index giving an individual engineer improved current awareness and search capabilities, the society's publications are brought to his attention in a positive way, thus increasing their impact on the members and the engineering community as a whole.

(2) Author or editor abstracting and indexing can be utilized by Engineering Index to the extent that it cuts down on the intellectual work of analyzing articles.

(3) When timing can be worked out, it will be possible for Engineering Index abstracts, or Engineering Index edited source abstracts to be published along with the article in the primary publication.

(4) Members subscribing to a personal current awareness service,[3] or using retrospective search capabilities, or using the merged published indexes can be assured of services beyond society publications and even cutting across disciplines.

Plans for 1966: It is planned to extend the literature coverage on the plastics and electrical-electronics fields to the full breadth desired. Estimates made with the aid of the liaison committees indicate that the coverage will be about 30,000 articles per year. This excludes patents but includes symposia and "separates" from technical meetings.

Working with a limited number of company laboratories on a cooperative basis, trial runs will be initiated on a Selective Dissemination of Information (SDI) service in anticipation of offering the service on a subscription basis in 1967. This experience, along with other feedback obtained from the cooperating societies, will give information as to the adequacy of the literature coverage and the suitability of the abstracting-indexing service.

It is also anticipated that whatever weaknesses may appear in the use of role indicators can be corrected as a result of this extensive feedback operation.

During 1967 it is planned to place the established operations on a firm basis so the quality, promptness and costs can be established. Negotiations will be under way with other engineering professional societies so that production in 1968 may be extended across the entire spectrum of engineering disciplines. During 1967 the conversion to the IBM system 360 will be made, so

[3]Often called SDI for selective dissemination of information.

that the more powerful and versatile configuration will be in operation for the extension to other fields.

Conclusion

While the ASM and EI projects are treated separately in the preceding portions of this paper, it should be strongly emphasized that both organizations are working jointly and in close communication and cooperation to develop an identical system of information processing for three fields of engineering interest — metallurgy, plastics, and electrical-electronics. ASM generates an abstract bulletin known as the Review of Metal Literature. EI publishes separate bulletins in the other two fields noted. All three conform closely in abstracting style and bulletin format. The computer system for generating monthly published indexes in these bulletins is identical and was developed jointly. Thesauri being generated for each of the three disciplines are identical in structure and format, as well as basic terminology, to the EJC Thesaurus of Engineering Terms.

Programs for deep indexing utilizing thesaurus vocabulary control, links and roles are in process of development and will also be identical. These programs are designed for retrieval of information in response to specific questions on demand.

The operating experience of ASM with both its Mark I and Mark II systems will provide an unparalleled opportunity for testing the new system in an operating environment. Close cooperation of EI with the two engineering societies in its fields of interest, through their liaison committees, will provide additional user groups for experimental retrieval of the large amounts of material being processed by EI in its Project CADRE.

Because of the cooperative aspects of this program in three widely differing disciplines, the joint activity of ASM and EI is rapidly approaching the stage where it can be tested as a true pilot module for the over-all Engineering Information System.

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(2) The EJC Engineering Information Program — 1965, by Frank Y. Speight, and N. E. Cottrell, Engineers Joint Council, March 1965.

Structure and Economics

BY WALTER M. CARLSON[1]

In providing a bridge between the recent past or present and what the future seems to hold for national engineering information systems, it is appropriate to consider the structure of any national effort that will actually evolve from these available components and to reflect upon the economic facts of life in the engineering information business.

As preface to an examination of the structure and economics of handling engineering information I would like to consider two comments made by EJC President Landis at the first National Symposium in January, 1962, which will help place the discussions of the 1965 Symposium in their proper context. Mr. Landis suggested that, in future years, the engineering profession would look back upon that day in 1962 as a starting-point, a beginning. The many comments and references made today confirm beyond doubt the wisdom of that prophecy. Jim Landis also noted that the engineering profession should logically be expected to learn enough about information handling to be able to help all the other professions design and install the information systems they will need; we should be careful to insure that our profession organizes its efforts on information systems so that the engineer users are served well; and further, that the engineering designers learn how to install effective systems for others.

I fully expect that the beginning made nearly four years ago will be amplified and accelerated during the next few years.

I confidently predict that a sound engineering approach to defining the structure of the nation's information systems and to developing the economic justification of new systems will turn out to be the crucial prerequisite to national programs of any kind.

Cost of Technical Communication

One further matter is pertinent as introduction to what follows — the responsibility of the engineering profession for effective technical communication in its own field.

It could be argued that the technical communication functions performed by the professional societies are more properly the responsibility of industrial, academic, or governmental groups who employ the engineers. I do not intend to resolve this kind of argument here today, but there are a few facts that should be reviewed to place the subject in some form of perspective. The topic is pertinent because the major purpose of engineering societies is to facilitate engineering communications.

Publications and meetings are the substance of technical communications fostered by engineering societies. A cross-section of several large societies shows us that 55 per cent of the total budget of an engineering society is allocated to technical communications. A survey of the five founder societies, plus ASHRAE, ASM, and ASTM provides this estimate. The total expenditures for the last full operating year of these eight societies were $19.5 million. Publications costs for the same period were $8.7 million, and the costs of conferences, symposia, meetings, and expositions were $2.1 million, a total of $10.8 million.

For comparison, we can look at the current estimates of the publication and meeting costs in science and technology of the U. S. Government. The most recent compilation by COSATI shows that the government's annual publication expense is $130 million, or nearly 14 times the amount being spent by the eight large societies summarized above. Similarly, the government's expense for meetings is estimated to be $40 million per year, or nearly 20 times the meeting costs of the eight major engineering societies. In general, these data include contractors and grantees of government agencies.

Obviously, similar data for these expenses in academic and industrial fields would be useful. To the best of my knowledge, no one has tried to develop even an approximate estimate for these two segments of the technical community. Whatever the figures turn out to be when they are collected, however, it is fairly clear that the professional societies are financially responsible for a small but important fraction of the technical communication in the United States.

Serving a General Audience

The extent to which the societies have a technical responsibility depends in a major way on how well they perform a public function free of competitive (or proprietary) considerations and free of other restrictions, such as military security. I shall examine this function from three points of view.

- The user.
- The formats (or media) in which the information appears.
- The channels of communication.

After the many ways it has been said today, it still needs to be said again that the structure of the engineering information system is highly dependent upon the kind of user being served. As shown in Figure 1, the description of a technical event may be addressed to three fundamentally different audiences. The general

[1]Director of Technical Information, Department of Defense.

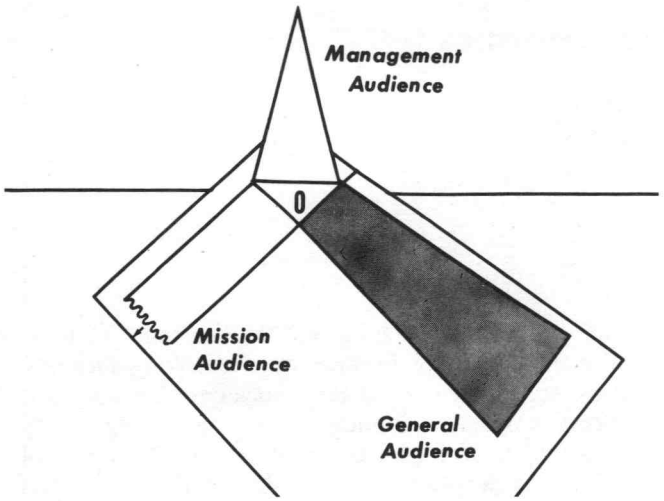

Figure 1. Structure of an Information System in Terms of User Orientation.

audience is undefined as to who they are, where they are, and when they will receive the information. The mission (or project) audience is known as to their function, their location, and (within limits) when they must have the information. The management audience is well known by name, by location, and by how soon they want the information. The potential general audience expands as time elapses after the event. The mission audience remains the same with time, and the management audience becomes smaller as time passes and the information works its way to the top of the organization.

All three audiences will be dealt with here.

The management system is internal to an organization, by definition, but we are slowly learning that there are common elements among these systems based on the technology involved.

The mission system is also internal to an organization, by definition; yet here, too, we are learning (as Dr. Rubinoff has emphasized) that engineering data on widely available equipment and components are common to every organization's mission-oriented system.

However, management and mission systems are not

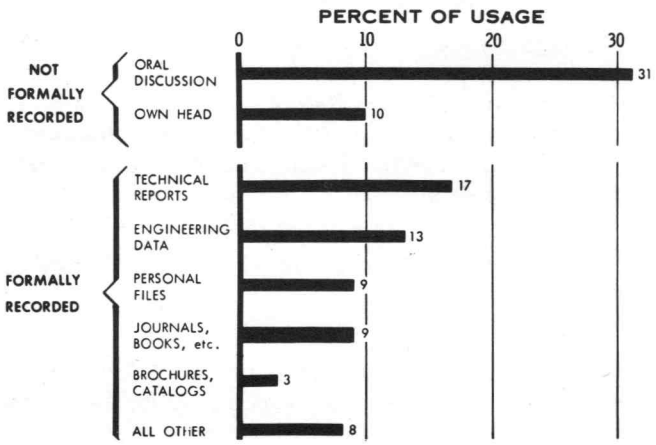

Figure 2. Communication Media Used by DoD Engineers.

the accepted province of professional societies today. Thus, this symposium has been devoted exclusively to the problem of serving the general audience, and the immediate actions that evolve from this symposium will be concerned almost solely with this general audience.

The communication media used by engineers to obtain the information they need in their work also establish a structure that has large implications for future systems design. I have taken the data in Figure 2 from a study[2] of 3,400 information-gathering incidents described by a random sample of 600 engineers in DoD whom we interviewed last year. A similar sample of industrial and academic engineers is currently being interviewed.

The results are that two-fifths of the information used is not formally recorded. About 31% is obtained by conversation with others — with colleagues (24%), with manufacturers (5%), with persons performing demonstrations (1%), and with speakers at meetings (1%). Another 10% is recalled from memory — a result of previous experience, previous conversations, or previous reading. Within DoD, the technical report and various forms of engineering data (that is, drawings, specifications, manuals) account for half of the formally recorded media, or 30% of the total. Personal files, composed of correspondence and notes, account for 9% of the total. The journals, texts, handbooks, and reprints — the basic input to the systems under discussion at this symposium — represent 9% of the total, and 15% of the formally recorded media. Manufacturers' materials and about ten other media account for the remainder.

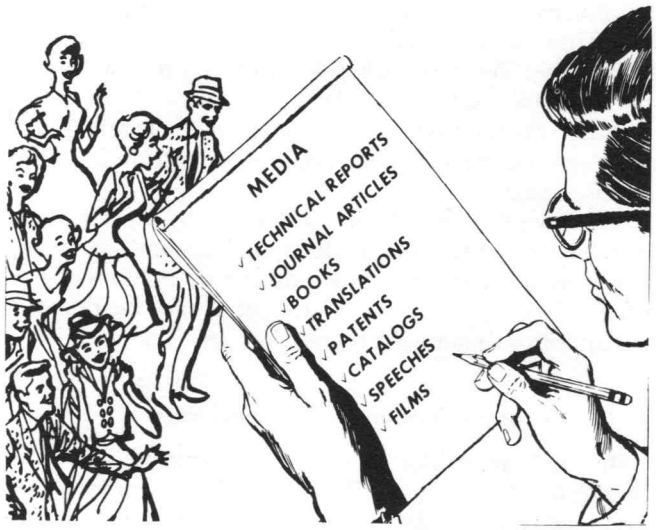

Figure 3. Media for the General Audience.

Before moving on to the structure of the channels, I would like to show that there is an interrelationship between the audiences and the media used to serve them.

The general audience is provided certain media, or certain forms of packages, with which it is quite comfortable. As shown in Figure 3, the technical report usually comes first in time. Other formats or media in-

[2]The study involved only the information-gathering incidents which occurred in performing a specific task. It did not include general reading or "current-awareness" activities.

clude journal articles, books, translations, recordings, patents, catalogs, speeches, and films. The author of material in these media is writing for whomever his words may reach.

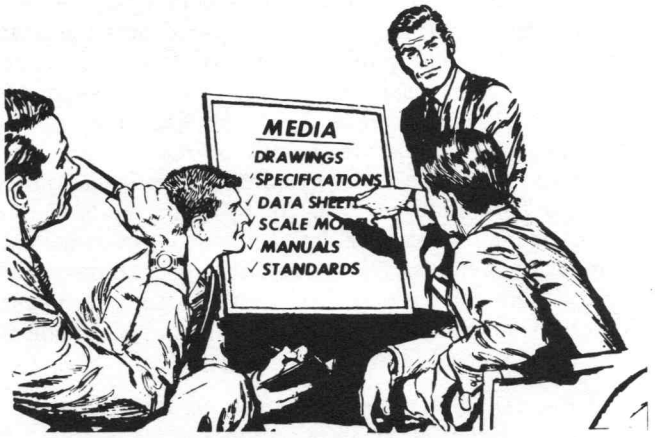

Figure 4. Media for the Mission or Project Audience.

As we turn to the mission- or project-oriented audience illustrated in Figure 4, the media used for technical communication are quite different. These media include drawings, specs, data sheets, scale models, technical manuals of various kinds, and standards. On the average, the audience for each use of these media is much smaller than in the case of the general audience, and the audience is much better known to the producer of the information. He therefore tries to tailor his material much more directly to the needs of the audience.

The formal media normally used to serve the technical information needs of the management audience include progress reports, special forms, technical development plans, budget back-up formats, program change proposals, intelligence estimates of various kinds, and several kinds of documents that are used to define long-range requirements as illustrated in Figure 5. The person communicating with management through these media is normally quite conscious of the level of management he is trying to reach, and he tailors his presentation to the keen competition for attention at that level.

With the audience and media structures thus defined,

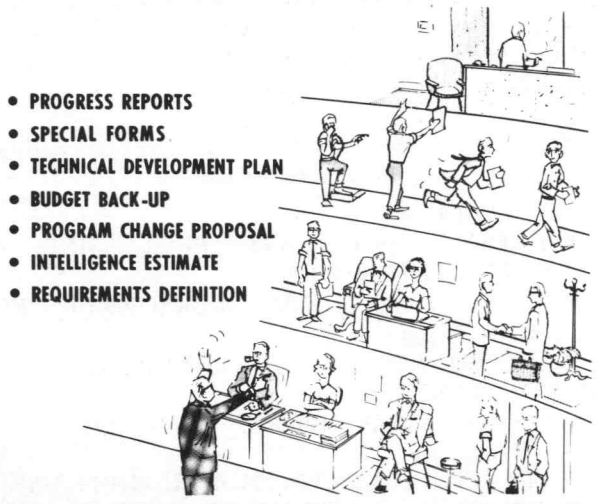

Figure 5. Media for the Management Audience.

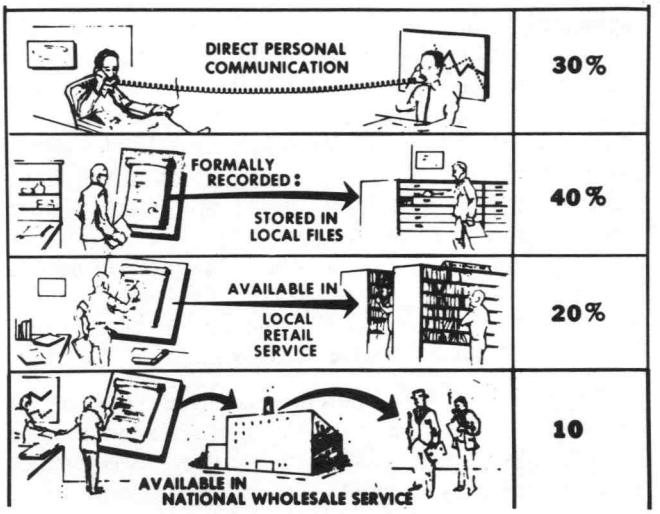

Figure 6. Communication Channels Used by Engineers.

we may now consider the communication channels used by engineers to get the information they need. About 18 months ago, several of us speculated that we could define the national network of engineering communication as a complex mixture of four components, but at that time, we had no data or ideas on the relative importance of these four basic channels. We still have no firm data, but I have developed some personal estimates of the current situation as shown in Figure 6.

My conviction is that direct personal communication accounts for approximately 30% of the transfer of engineering information in the U. S. today. Similarly, I estimate that the various published media which go directly from the point of publication to a desk drawer, book case, or a file cabinet are the source of about 40% of the engineering information used in the U. S. today. Organized local retail services, such as libraries, information centers, data groups, and assigned subject specialists, appear to provide in the vicinity of 20% of the information used. The large national centers seem to handle and disseminate about 10% of the material that engineers use in their work. I must re-emphasize that these are personal estimates.

There is an urgent need for determining the true nature of these channels and the load they carry. I sincerely hope that the next year or two will see a clarification of this particular structure; without such clarification, it will be virtually impossible to decide upon the economics of tomorrow's engineering information systems.

A summary of the system structure for a general audience is in order before considering the economics. As shown in Table I, the audience our future united

Table I. System Structure for a General Audience

AUDIENCE	— GENERAL
MEDIA	— RECORDED: JOURNALS, REPORTS, BOOKS, PROCEEDINGS, PATENTS
CHANNELS	— NATIONAL WHOLESALE SERVICE

About 10% of useful engineering communication in the U.S.

engineering information center will serve is a general audience. The media it will handle, or keep track of, are the recorded media closely associated with the general audience. The channel that the center will represent is that of a national wholesale service. The center can probably define as an objective that it will have some effect on about 10% of the useful engineering communication in this country. This is an ambitious objective, but it is a realistic one. The question now is justification.

Economics and Communication

The matter of economics has received little formal attention, and it is time for some daring expeditions to be undertaken into this uncharted territory. Some statement of goals may stimulate the kind of action we need.

Here follows an examination of where we stand today, a consideration of the potential cost of changing the situation, and a speculation on where the money is coming from.

Table II. — Today's Balance Sheet for Technical Communications
(In Millions of Dollars)

	Costs	Income
EJC Member Societies	13.0	10.0[1]
Engineering Index	0.9	0.4
Engineering Societies Library	0.4	0.1
Totals	14.3	10.5[2]

[3]Based upon publication sales and net advertising revenue.
[2]Deficit is made up by allocation from $8.0 million per year dues collected by societies and by NSF grants to Engineering Index.

Today's balance sheet on technical communications at the United Engineering Center is a somber one as shown in Table II. The estimated annual cost for publications and meetings for all EJC member societies is about $13 million. The Engineering Index is spending $0.9 million annually, and the Engineering Societies Library costs are $0.4 million per year, or a total for all three components of $14.3 million per year. The income from societies' subscriptions and sales of one-time publications amounts to about $7 million per year, and the net proceeds from advertising (after deducting an estimated 40% of revenues for cost of selling the advertising) add about $3 million more, a total income of $10 million per year. Current sales of the Engineering Index are $0.4 million a year, and the billings by the Library to its customers are about $0.1 million a year. The annual deficit of about $4 million is made up by allocating about $3.5 million from the $8 million dues collected by the societies to support of the societies' communications programs and to support of the library. The remainder is made up by NSF grants to the Engineering Index, since the Index has no way at present to obtain support from the societies.

This, then, is the situation that we have been talking about changing through fresh approaches to technology, to scope, and to organizational alignment.

Tomorrow's costs for the united engineering information center and its related systems will be large. No one can give firm estimates yet, but some general figures help guide our thinking are shown in Table III. The development of the proposed system, as visualized by the advisory panel of information center managers and the EJC Information Systems Committee, will cost in the range of $10 to 20 million spread over the next five years. The plan published by EJC three years ago indicates that the peak expenditure rate for system development should be reached in 1968 when the switching center goes into trial operation. Once proven, the proposed system can be expected to require in the range of $5 to 10 million per year for operating costs at the center, including costs of links to other governmental or industrial centers. These operating cost estimates are derived from current experience in the large government centers established to handle large volumes of technical report and journal literature.

Table III. — Tomorrow's Costs for the United Engineering Information Center

- DEVELOPMENT OF SYSTEM — $10 — 20 million spread over 5 years, maximum in 1968
- OPERATION OF SYSTEM — $5 — 10 million per year at center

With costs of this magnitude in mind, it may be desirable to reflect on who would, and who would not, benefit from the system before discussing where the money could come from. Where are the benefits likely to be? There are some favorable places and some that are unfavorable, almost by definition as shown in Table IV.

The likely benefits of the future systems need much more study, but they can be described. First is the national cost of cataloging, indexing, and searching for the 50,000 to 100,000 important items of open engineering literature that are published each year. No one knows how much is spent by countless companies, institutes, and agencies for doing essentially the identical operation on each of these books, reports, articles, and patents. The proposed center would probably reduce this national cost to one-fourth or less of the current cost.

Another factor is the proper use of technical talent. The time spent by graduate engineers searching for the data they need is not precisely defined today, but most engineering managers consider such time to be essen-

Table IV. — Pros and Cons of United Engineering Information Center

FAVORABLE
- REDUCE DUPLICATE PROCESSING OF OPEN LITERATURE
- USE LOWER COST PERSONNEL FOR SEARCHING
- HIGHER QUALITY ENGINEERING

UNFAVORABLE
- CONTROLLED INFORMATION NOT AVAILABLE
- PROJECT COST CONTROLS INHIBIT USE
- INEFFECTIVE LOCAL SERVICE

tially nonproductive. The development of an orderly and comprehensive national system will provide the opportunity — for those who will seize it — to relegate much of the searching to technicians or clerical personnel. Obviously, this will reduce the average salary cost for doing a job. It is interesting to note that a 1% decrease in average salaries to do this country's engineering work is equivalent to about $100 million per year.

Quality engineering is not necessarily related to the number of man-hours consumed. It is much more intimately tied to the certainty with which key decisions are made in the course of engineering work. Any system that provides better access to what is already known will open the door to more certain decisions by those who choose to use the system. The installed cost of capital facilities and public works in the U. S. is more than $30 billion every year. The prospective cost of the United Engineering Center is .03% of this amount.

There are some unfavorable aspects, however. If a single, national center is established for the open literature, the organizations with controlled information (for proprietary or security reasons) will have to install compatible systems in order to get the full benefit of the national system. This may be very expensive, especially if someone truly has need for real-time inquiry response. Another factor is that our project control systems have no way of measuring how efficiently internal engineering man-hours are spent, but they clearly identify all expenditures for outside services that must be purchased. If an engineer has to process a purchase order to use the national system, he simply will not use it. Finally, and most important, the value of the national center will be only as high as the quality of the regional or local units that are tied to it. If these local services are staffed by uniformly low quality personnel or give low quality attention to practicing engineers, the center's potential will never be tapped by the intended user.

Table V. — Financial Impacts

ENGINEERING SOCIETIES — Cost per year per member	
$6 would develop system	
$15 would operate it	
INDUSTRY — Cost per year per engineer employed	
$6 would develop system	
$15 would operate it	
GOVERNMENT — Cost per year per engineer supported	
$10 would develop system	
$25 would operate it	

For about 10% of the information needs of engineers.

Let us assume that we wish to proceed with this venture.

What would the financial impacts be under certain conditions? Table V provides some estimates.

If the engineering societies that comprise EJC tried to provide the financial resources, the cost for each of five years for each of the 500,000 members would be $6 to develop the system and $15 per member for each year after that to operate it. Since industry employs about 500,000 engineers, the same figures apply for the basis whereby industry would subsidize the development and operation. The Federal Government employs or supports about 300,000 engineers. The cost to the government would be $10 per engineer for each of five years to develop the system and $25 per year after that to operate it. The potential this system has for supplying about 10% of the engineers' information requirements is a prospect worth close attention.

Raising the dues of the engineering societies is not a realistic means of raising funds for this purpose. This leaves the question with industry. If there is interest in funding the effort, it will be difficult to organize that interest and create an effective method for collecting the funds. My own view is that this is where the money should come from.

There does exist the government's program for national systems discussed by Bill Knox. This must be taken into account when seeking funds for a venture of this nature, but such an approach might be considered as a resignation that industry doesn't have the vitality to act in this particular matter.

Whatever the course ahead, I am optimistic.

The structure of the system is becoming clear. The technology to proceed exists. The user and his needs are sufficiently defined to warrant large-scale experimentation with new concepts and approaches. The current arrangement cries out for corrective action and improvements. The blessings are mixed for a national center and its associated network, but the economic potential is enormous if the proper steps are taken. The costs loom large, but the sums are small compared to existing costs of information systems that will be affected.

Our knowledge of the structure and the economics, limited though it may be, gives a green light for a firm program to create the united engineering information center and its associated network.

Speakers Panel and Discussion

MODERATOR: ROBERT M. BOWIE[1]

Panelists:[2]
Burton W. Adkinson
Walter M. Carlson
Norman E. Cottrell
William J. Harris, Jr.
Bart E. Holm
Eugene B. Jackson
J. C. R. Licklider
Morris Rubinoff

DR. BOWIE: First of all I should make an apology on behalf of one of our speakers, William T. Knox, who cannot be here.

We have now reached that part in the program at which it is proper for us to interact in real time with the speakers of the day. I would like to take the prerogative as moderator of the discussion to ask the first question. I would like to turn to Dr. Burton Adkinson who spoke first, as to the nature of the requirements for an Engineering Information System. I would like to inquire as to the kind of timetable he sees ahead for the setting up of a system of this kind. How soon will some kind of definitive action be required in order to meet the government's schedule?

DR. ADKINSON: (author) I can give you some indication, but there is no definite information. This actually centers on the on-going activities in various government agencies having missions and which are running national systems in support of their mission, such as space, atomic energy, health with the medical information program, and there are others, such as those arising from the State Technical Services Act and the multitude of programs that Commerce is developing of specialized nature that will be national in scope. These are moving forward rather rapidly. Within the government we are quite concerned about how we are going to develop switching mechanisms with which to effectively transfer information in these systems. But as these systems within the government develop and as others outside such as in chemistry move along, the longer any society or profession having an interest in developing a national system waits, the more the requirements will be prescribed for them by earlier actions taken by others. My estimate is that a year to two years is about all the time anyone has to get a system into operation at least on an experimental basis.

DR. BOWIE: We have heard the figure of two years as a fair guess as to when we will have to have an operable plan available. Now, are there any other questions that have to do with timing?

VINCENT F. MATURI, Science Information Exchange: This is directed to Dr. Licklider. Concerning your remarks about all these system components being available, I'm wondering if because of the high cost, what timing schedule you see for their general use. Everyone would like to have an efficient computer with all accessories, but one always has to think of the cost.

DR. LICKLIDER: (author) In the area of large memory (secondary memory, photographic in nature), the costs are going to be rather surprisingly small. For example, the investment in a facility for storing a page of typewritten material will be about the same as the cost of a copy of that same page from an office duplicating machine. Computers themselves are not so inexpensive as that, but in many information processing activities, the cost of the computer processing is only a relatively small part of the total. For example, in one instance of machine translation from one language to another, only about 13% of the whole cost is computer cost. That is largely due to the fact that the computer's translation is not a very complete job. The handling of the graphics — that is to say, getting the diagrams transferred from the original document to the final one, getting them re-labeled — is more expensive than the cost of the computer processing of the strings of characters. In any event, it isn't always the computer itself that is the expensive part. By and large, when people have to read things, the cost of reading is the dominant cost in the system. Telecommunication of the kind of information we're talking about — getting documents from one place to another over wire facilities — is fairly expensive, but it doesn't compare with, say, getting the same amount of information over long distance telephone by voice. Digital communication of alphanumeric characters is much less expensive than ordinary analog speech communication. The digitally encoded information goes over an ordinary telephone line, at about 2400 bits per second. According to my conservative rough rule of thumb, that is more than 240 characters per second or more than 24 words a second. After 7 P.M. the long-distance charge is, I think, only a dollar for three minutes, coast-to-coast.

DR. BOWIE: Next question, please.

ROBERT CAMPBELL, The Burroughs Corporation: I have a question somewhat related to the last one, concerning both economics and timing. The discussion today has been mostly concerned with the overall system, its operations and the general approach to setting it up, and how users might be involved with it. Another important question, which has been touched on only lightly, is concerned with the terminal equipment for use of people who are involved in the system on an on-line basis. As has been stated, equipments performing the basic functions are currently available; however, there seems to be a wide gap between the cost of such equipments at present time and the necessary cost if their use is to be widespread. Would anyone on the panel comment, first on the possible rapidity with which costs of this type might come down and second, what cost targets would be necessary in order to make ter-

[1]Technical Management Consultant.
[2]For biographical data, see page vi.

minal equipment usable in practical applications. I have reference here to equipments capable of performing the various functions, for instance, which were described by Dr. Licklider in his luncheon address.

DR. BOWIE: Thanks, Bob. Is there anyone who would like to take a shot at that one? Walter?

MR. CARLSON (author): You cannot talk about costs or prices in this kind of activity in a vacuum. You must define what you're talking about. If your job is to collect some information for design or a maintenance procedure for some existing equipment, I expect that, as a part of your job, whatever it may be, you could afford to spend, normally say, one hundred dollars to collect the information for any one information-gathering incident. On the other hand, if your job is to turn out a proposal, particularly a proposal with the kind of short time-fuse that government agencies seem to set, you may be able to put a price tag of several thousand dollars on that one information-gathering incident because you are using your highest corporate talent in the most intensive fashion to meet an extremely short deadline. You will want something on-line and you can justify spending considerable money to get that piece of information immediately, for if you don't get it, you aren't going to get the contract.

This says that we'd better establish what we're talking about in the way of information gathering — what is its purpose, what is its economic value, what is the cost, what risk are you taking if you don't have it. Then you can decide whether or not you need on-line equipment on your own desk, or in a particular office, or in a nearby area. If circumstances like the proposal-preparation incident occur only once every three years, you don't really have much justification for such on-line equipment. But if it happens day in, day out, I suspect that you have the justification. Certainly the more conventional design kind of activity is going on in uncounted places day in, day out, and this may add up to a lot of money, but it certainly doesn't require that each individual designer have some kind of on-line gear.

We haven't talked enough about who the system serves and for what purpose. This is what the next phase, of system development in my judgment, is going to have to consider, and I challenge people to start defining information gathering incidents in terms of the economic potential of each. What are we doing it for?

DR. BOWIE: Burt Adkinson's comment does seem to raise a question that needs to be resolved. It relates to the dichotomy between the short time schedule facing us and the time consuming need to find or develop the equipment to be used in the engineering information center. If we do this search for equipment on a trial-and-error basis or wait until costs are right, can we meet the kind of time schedule that Burt talked about a few minutes ago?

MR. CARLSON: The cost of performing a calculation on a computer when I got into this business in 1964 might be given an index of 100. Today it is 0.0001 — orders of magnitude different. Somebody, in those early days, felt justified in building those highly inefficient computers; indeed, the justification was there and most of you know that the urgency was also. In the information field, history shows that we're going to tackle the important ones, the tough ones, the high-risk jobs. To do this we shall put some equipment together, no matter what the cost. Then we'll learn how to engineer equipment for much more efficient operation.

DR. ADKINSON: I'd like to comment, then I'd like to ask Dr. Licklider a question along the same line. The question that was asked before, assumed that everybody had to have the same sophisticated equipment to meet their service needs. This might be nice but it isn't necessary. There's a great variety of output machinery that could in some instances be very useful and much less expensive. Other equipments would be very high priced and sophisticated and the need in each case would have to be assessed. I think this is what Mr. Carlson was saying. There's another area I'd like to explore and here I don't have enough information, but I hope Dr. Licklider has. What about time-sharing of facilities?

DR. LICKLIDER: It's implicit in this notion of multiple access to computers that several or many people use the same computer at essentially the same time. On M.I.T.'s Project MAC, there's a 'bookkeeping' limit that says there may not be more than 30 people simultaneously operating one computer. The reason is that the project management likes to keep the service good enough not to discourage anybody who has 'logged in' and is at work on line. There are, however, about 150 typewriter and tele-typewriter consoles around the Institute. I saw a demonstration recently in which Professor Fano held forth for 15 or 20 minutes, and the machine reported from time to time how much time it had spend on *him*. When Professor Fano finished his demonstration, he said he had used about $5 worth of computer time. Thus you divide the running cost of the computer by something like 30 in the present Project MAC case. Now, about consoles: the present state of that art as far as announced products are concerned, is that small oscilloscope displays capable of presenting alphanumeric characters at a rather high rate are just now coming down to match computer-operated typewriter costs. Several concerns can supply these, with keyboards, at less than $100 a month per console installation.

DR. BOWIE: I believe, Bill, you had a desire to comment.

DR. HARRIS: (author) I believe the people in this audience and some of the people on this platform are among the more sophisticated in the community dealing with the information problem. It has occurred to me that a fair fraction of our audience today, and of the potential users during the period of time the system is becoming operational will not be versed in the com-

puters and consoles discussed by speakers. Do you anticipate that the system must, from the very beginning, be designed exclusively to provide its output through a computer console or will there not also have to be a more conventional output?

DR. BOWIE: Would Mr. Cottrell answer that one?

MR. COTTRELL: (author) It is easy for us to become overly preoccupied with hardware. I think that those of us who are operating systems in the real-life environment today see that there are considerable improvements that can be made before you go into much more complex and sophisticated equipment such as have been inquired about. The sophistication of equipment that may be used depends on the important element of response time. Experience has shown that response can be divided into two categories, immediate and delayed. Sometimes a quick response is required in acknowledgment of the question. In other words, if you are going to depend on some centralized or switching network system to provide information for pressing needs, the first thing you want to know is, are you going to get an answer. The response to a telephone inquiry may be, "Yes, we do have good coverage in that particular field, and we will be able to provide an answer for you. When do you need it, 24 hours or 48 hours?" In many cases, experience shows that this is entirely adequate for the purpose. Let's be practical. I don't think we have to go immediately to remote consoles to examine this problem practically. I suggest that we very carefully set up pilot programs before we make any large-scale investment, let's take one of everything, line them up in a real-life environment, have intelligent people use them and then carefully study the results.

DR. BOWIE: I think we've heard quite a bit now about the end product and the output devices. I wonder if there are other questions from the audience?

DAVID STAIGER, Society of Automotive Engineers: Mr. Carlson, I'd like to direct my comments and question to you even though my thoughts touch on several of the panel members' statements.

My first reaction to the $6 setup cost and $15 operating cost per member per year for an information center is one of awe. We had thought at SAE we'd been in data retrieval for several years, but I'm beginning to wonder whether this is really true. We've worked from the bottom or source end of the problem and, therefore, these economics are interesting to me in looking for a practical approach to data retrieval both now and in the future.

By way of background, our system is not too sophisticated, but does contain these elements: computer storage and manipulation of indexing terms; magnetic tape storage of abstracts; automatic quality typesetting from computer storage; microfiche of all literature, a monthly current awareness service to 30,000 engineers; and cumulative printed indexes for modest retrospective searching. The cost of the intellectual and mechanical part of the "finding" service, that is, indexing and abstracting costs plus computer charges run around $6,000 a year for about 1000 documents.

Offsetting this charge has been a growth in sale of documents through the current awareness service so we came out with a tidy net as a result of data retrieval. However, the setup charge just quoted of $6 times 30,000 would quickly put us out of business.

Further, visits to the ground vehicle industry and some to the aerospace industry show that the typical engineer is nowhere near the point of requiring a console at each desk — in fact, they are several steps away from this sophistication. I'd appreciate it if Eugene Jackson as an ex-General Motors man would comment on how many Chevrolet, Pontiac, Buick, Oldsmobile, and Cadillac engineers are at the point of sophistication about which we've been talking.

Hence, I want to question what the $6 charge for each of the nation's 500,000 engineers would cover. It doesn't compare with our figures, so is it for consoles on everybody desk?

DR. BOWIE: I think we have two questions here.

MR. CARLSON: If I understand the question, the problem posed starts with some semantic difficulties with the word 'data.' As it is used here, it is apparently equivalent to the term, engineering information, used throughout the symposium. The word 'data' has been used throughout the day to mean facts — single, isolated facts, like the boiling point of water or the melting point of lead. I gather you're not talking about fact retrieval, you're talking about document retrieval. Returning now to your question, I was not talking about consoles. I wasn't talking about anything fancy at all. I was simply talking about capturing the world's open engineering literature and putting it under some kind of bibliographic control, under some sort of storage and retrieval capability at a switching center that could tie into your SAE system or into General Motors' system or anybody's system. The cost of developing that capability over a five-year period would be an average of $6 per member per year. Once the system gets into operation, it's going to cost $15 per year per member for operation, plus console, plus all kinds of fancy processing and communications, plus anything special you want to do with the information. Certainly, the special processing is not going to be done as part of the service rendered by the center. So I was short of the cost of the consoles or anything like that.

DR. BOWIE: Your figures covered, I believe, only the cost of gathering the information, placing it in retrievable form on a record in the Center and then making lines available out to the regional centers at least.

MR. CARLSON: Or having the center at least know where the information is.

MR. STAIGER: Mr. Chairman, this discussion has isolated the cost of the described information retrieval system and leads to a second point I wanted to raise. Mr. Carlson's remarks relate to the price tag for the

finding service — the storage of the data, the development of the retrieval system, and the ability to call upon it and to find things. This price tag does not represent the value of the data itself, but rather Mr. Carlson's best projections at this point of the cost of the finding service used to look for it. In SAE, we are packaging within the value of the technical data itself, the overhead necessary to find it. I assume you have not approached your calculations by regarding information retrieval as a marketing device for technical information, which information has a real dollar value to the user.

MR. CARLSON: Would you kindly tell us what that dollar value is, I would like to know.

MR. STAIGER: The dollar value is what it is worth to the user. To give you an example of dollar value variations, there have been cases where it is difficult to sell good technical data for 50c per paper, delivered. There are other cases where one technical paper costs a man about $50, and price was no object. So value can fluctuate with the need, the subject, the timing, and the person who is ordering it. There is no fixed answer, except that such information is a marketable commodity, and it is not free. This is the main point. It costs money to develop and process it. The handling cost including retrieval services, I feel, should be part of the initial price of the technical literature.

MR. CARLSON: I don't want to be contentious here, but I've exposed myself in telling you what the projected costs are, and I wish you would tell me what price you're willing to pay for these services.

MR. STAIGER: A separate technical paper, including the data retrieval we're doing, come out on the average to 75c each.

MR. CARLSON: And how many a year does a man get?

MR. STAIGER: This varies from nothing to about 1,000, the latter if he happens to be a librarian getting one of everything. We issue in the neighborhood of 1,000 technical papers or articles a year.

MR. CARLSON: What's the average number an individual gets?

MR. STAIGER: I would say, an average member of our society gets 5 or 6 a year.

MR. CARLSON: Alright, 6 times 75c is $4.50 per year.

MR. STAIGER: That's right, but that covers the total price of processing and delivery including our retrieval system.

MR. JACKSON, (author): As to the other question, on the situation in General Motors, I didn't find anyone in the list of registrants from there, so I'll speak as a stockholder. At least up to the first of February there were not a large number of engineers in General Motors who were at the stage where they would be able or willing to operate a console. There are some who would be. I might say that the awareness of the value of information on the part of the professional engineering segment of the General Motors Corporation has made a gratifying series of strides forward in the past nine years. The institutional advertising campaign of the Corporation that appears in national magazines with the theme: "General Motors is people," features engineers one month, physicists another, and in the month of August (if you look in any of your national magazines) you'll find that "General Motors is librarians." They reveal there that there are 22 libraries of the Corporation in this country and they have a total of 78 people on their staffs.

I think that the matter of an interloper between a man and his literature is pertinent here. While Walter Carlson thinks that there can be a low-level person doing the literature searching, I don't quite agree. I say that you have to use as qualified a person as you can to do your literature searching. The advantage of your advanced system is to get the material in a manageable form so it can be used by a person who is qualified to make the technical judgment on the information. More often than not the request at General Motors was 'Get me the information quickly and please don't bother me with where you got it or how; I just want valid information and I want it fast.' Rapid service in location of critically needed engineering information must characterize facilities intended to be of use to industries.

DR. BOWIE: Norm, did you wish to make a comment?

MR. COTTRELL: I think that when you start talking about cost, you've got to be very careful that we're talking about the same thing. I don't think you can properly compare a system which is providing a partial coverage of the technical information field against one that is carefully examining the total spectrum. When you're talking in terms of cost, if you would take the cost figures from SAE and translate this in terms of covering every conceivable facet of published technical information, and government reports, patents and the works, then you begin to come into some type of valid cost relationship.

DR. BOWIE: In summation, one can gather from the discussion thus far that we are not yet able to place very accurate dollar figures on the cost of equipment or service. I would like to suggest that we now move from the equipment end and have some questions directed toward the system.

PAULINE ATHERTON, American Institute of Physics: A question for Mr. Carlson. I want to make sure that I'm properly interrelating the comments of the speakers. Bart Holm mentioned that the Engineering Index coverage should be something like 60,000 documents. Mr. Cottrell mentioned a pilot system which was

mainly based on what I would call an abstracting and indexing service. Are the estimates for the national engineering information center based on that estimate of documents and that type of document in the system, or does it also include the costs of publication of the original journal?

MR. HOLM: (author) Since I was the first speaker to address this particular point, let me comment on the context of the data. The Engineering Index handles at the present time, or did in 1963, when that figure was generated, about 40,000 articles per year. The study that was made for them by Battelle said that the next appropriate level of coverage would be 60,000. There was no intent in that study, as I recall, to indicate that this was the total engineering literature, world-wide, but rather the next logical step of coverage.

MR. COTTRELL: In projecting what the overall costs would be of operating a comprehensive system we were talking about encompassing all of the world's engineering literature in this collection.

MR. CARLSON: Pauline, my figures did not include the production costs, or the publishing costs. They are handling costs, after publication. They include a certain amount of the indexing and abstracting on the assumption that it's going to be a long time before we get indexing and abstracting at source fully developed. Those were not only journal articles that I used in my 50-100,000 per year figure. I included patents, open technical reports that come from the government, and some of the books, monographs and proceedings in addition to the important journal literature. The full panoply of these are built into my operating figure. That figure is the sum of Bart's figures, some of the things that Norm alluded to in the patent area, and other items of that sort. This sum could probably reach as high as 100,000 per year assuming that all individual items are significant. However, I don't make that assumption.

MR. HOLM: There is one other piece of data which will tie this up fairly well. A few years ago Charles Bourne of the Stanford Research Institute analysed the world-wide publication of technical articles in all fields, science, engineering, etc. If you go back and review his data you will find he estimated 100,000 articles published per year at that time for all engineering. It's in the same range.

DEAN GEORGE TOWN, Iowa State University: Mr. Carlson spoke about the government, technical societies and industry. There is another group here today on whom the matters under discussion have a great impact — namely, engineering educators. Certainly we could use, and will use and want to use, this type of system in our educational activities, for instruction, for research activities, and in the case of our state universities, for our work throughout the state with industry in our extension activities. A number of questions immediately come to mind, and one of them is cost; we are not profit-making institutions. I am not so much worried about the costs of the terminal equipment or the originating equipment, but there is a substantial cost of transmission. But aside from the question of cost, the subject matter has, I believe even greater implications on education itself. How are we going to educate young engineers to use such a system? Also, how are we going to train young engineers to design such a system? There are many such questions that come to mind immediately and I am wondering if the panel, or any members of the panel, have been doing any thinking about the implications of this information retrieval system in the general field of engineering education?

DR. BOWIE: Does anyone wish to address himself to the place of the university in the overall system as contemplated?

JULIUS ARONOFSKY, Socony Mobil Oil Co.: My activities in education as related to EJC have dealt primarily with computer applications in the engineering disciplines, rather than in the retrieval of information. I of course, recognize that there is an interconnection particularly in the use of computers for educational purposes. I strongly believe that education at the engineering college level must be taken into consideration when discussing these new types of facilities. It is important, in my opinion, that the students become familiar with such a system and learn how to use it. It is apparent that only a small percentage of the scientists in research departments and engineers in engineering departments make effective use of libraries today. We are speaking of an order of magnitude increase in one's ability to retrieve information. For example, one of the speakers talked of engaging in a dialog with a computer and carrying out an adaptive search. One must learn how to carry out such an adaptive search.

In planning the pilot studies that were mentioned, surely consideration must be given to the needs of undergraduate education as well as to the graduate work and the faculty education going on now at the university level. I feel confident that the EJC will take this into consideration.

DR. BOWIE: I would like to ask Dr. Overhage if he would care to comment with reference to the place of the university in this proposed engineering information system. How is the university going to fit in and in what manner do we make use of its capabilities in a system of this kind?

CARL OVERHAGE, Massachusetts Institute of Technology: The libraries of our large universities are of course quite centrally involved in this question and the plans of the Engineers Joint Council and similar groups in providing information networks are of great concern to all of us who are trying to wrestle with the information transfer problems of the university. It is clear that in the future the university library must become a part of these national networks that we are talking about if it is to provide effective information transfer services

to the members of the academic community. I think in the same vein, we must see to it that our students as well as our faculty learn how to make effective use of such systems. But I'm confident that this will be coming; indeed, I'm very optimistic about the future of information transfer. In that context, I would like to address a question to Walter Carlson.

DR. BOWIE: Could I first ask you a question that is part of what you have just said? Is there not a responsibility within the university to see that the next generation of students shall know how to use the system and also how to design it? I believe George Town alluded to this. Is there some thought being given to the way in which the university can serve these needs?

DR. OVERHAGE: Yes, I think so. At M.I.T. for example, the project of which we are thinking in the field of information transfer is being established in the School of Engineering, with the specific objective of not only thinking about the future of the university's information transfer system, but also with the objective of establishing information transfer engineering as an emerging discipline in the school of engineering. We hope to train students not only in the *use* of such a system, but also in its *design*.

DR. BOWIE: Carl, I notice that one member of the panel, Morris Rubinoff, would also like to comment on this, and then could we have your question?

DR. RUBINOFF, (author): I thought I should mention that there is already such a program launched within the Engineers Joint Council family through the American Society for Engineering Education. It is a program which is being spearheaded by Bob Taylor of Lehigh University. It has three major planks in its platform. One is, how do you get engineering undergraduate students, and graduate students for that matter, to recognize that there is a library and that they ought to be using it? This is regardless of consoles or mechanized systems and has reference to the use of just plain books in the library. The second plank is, how do you convince the faculty to urge the students to use the library? Maybe the faculty members will then also use it more themselves. Thirdly, and very importantly how do you get universities to recognize that adequate library resources must be made available and how do the universities get the money to do so? Since I've really spoken in place of Dean Arthur Thompson, who is spearheading that effort in ASEE, I'm going to call on him, if he wants to say a little more on the subject.

DEAN ARTHUR THOMPSON, Boston University: The Information Systems Committee of American Society for Engineering Education has taken its leadership from Dr. Rubinoff who was its chairman for some years, when I was a member. I recently have been made chairman. There are two main projects that the committee is operating with, the first being the one that Dr. Rubinoff just mentioned. This spring with Professor Taylor at Lehigh University, we hope to get this project started. We spent some six months getting funds, so we could hold a conference that would plan a program. This spring we are definitely starting and we do have support for a conference. We hope in May to design a two-or three-year program to bring into the universities this sensitivity and this knowledge for information media.

The other project, just about concluded, is a national survey of the status of computers, both analog and digital in undergraduate engineering education. And you find a tremendous spectrum here. Certain schools, some of which have been represented in this discussion, are doing amazing things, but for the most part, digital computation in undergraduate engineering education is quite routine. The problem stems from lack of funds, availability of equipment, tight curricula and lack of knowledge of computer use in some faculties. I think it will take a while before all our undergraduates have a working knowledge of digital computers. There is progress, but the use of the computer at the undergraduate level is routine while sophisticated uses including engineering design, are yet to come.

As to analog computation, I have a feeling that many universities never heard of it. It just doesn't seem to be used the way we think it should be.

So in ASEE, we are focussing on these two areas, and hope to aid in the national consciousness of these two interesting uses of the computer.

DR. BOWIE: From this discussion about the university and the training of student engineers going on it certainly seems that this is a very interesting and important part of the proposed system. No doubt, this will be taken into consideration as we do our system planning. I believe there is another comment from the panel. Were you going to make one, Dr. Licklider?

DR. LICKLIDER: Just a brief comment. There is now a developing wave of activity in the field of computer assisted instruction. At least a dozen leading universities are involved: Harvard, M.I.T. Berkeley, Stanford, UCLA, UC-Irvine, Texas, Illinois, Michigan, Michigan State, Florida State, to name a few. The present work is mainly concerned with courses of instruction that come out of the computer, as it were, and with which the students interact. But everyone sees a potential connection between computer-assisted instruction and the information facilities — the library and information transfer network of the universities. When that becomes a reality, it will be really significant.

DR. BOWIE: Before the implications grow too large and exceed the size of the national budget, we had better change the subject. We're holding two questions. There's one from Carl Overhage and one from Mr. Juhasz.

STEPHEN JUHASZ, *Applied Mechanics Reviews*: About two months ago, Dr. Adkinson had a meeting at the National Science Foundation and he mentioned something which is very essential to the entire national system. This is a question of standard bibliographic

headings. We are interested because we are publishing critical reviews and also state-of-the-art surveys and we do need standard bibliographical headings. There is also the question of transliteration. It can be asked, why do we bother with transliteration — a computer can do it. Though a computer can do a lot of things it cannot tell for example, whether a Russian name is a transliterated name or whether it was originally published in the Latin alphabet by somebody whose name is Russian. I believe there is a great need of activity to solve these problems.

DR. BOWIE: Have you addressed a particular panelist?

MR. JUHASZ: No, really, my remarks were based on Dr. Adkinson's comment that he made about two months ago, with which I agree wholly.

DR. BOWIE: There's time for just one more question. We have promised Carl Overhage he could present his question, if he wished.

DR. OVERHAGE: I'll be very brief and ask Walter Carlson if he can help me dispel some gloom that may have come over the audience as a result of his 10% estimate of the use of engineering literature to answer the questions of practising engineers. I won't quarrel with the estimate, but I just believe, and I hope he will join me in this belief, that with the very much better information transfer system of the future, that figure will go up.

MR. CARLSON: Carl, I said that 70% of the information used by engineers is in the form of engineering literature. I said that only 10% of it goes through national wholesale services. Some 40% of the remainder goes directly from the publisher to the consumer; another 20% goes through the local library services. What I was trying to point out is that we're talking here about a national wholesale service and we ought to be very cautious to be sure that we do a good job with that 10%. I didn't say this, but I am sure we all realize that the people who do a good job on that 10% are going to have quite an impact on the other 60%.

DR. BOWIE: There's an old adage which says that if the discussion is cut off while it is hot, the symposium will be well and favorably remembered. So we shall close this one abruptly at this point.

Summation and Conclusions

BY NORMAN E. COTTRELL

The ambitious plan to establish a united engineering information center and network requires a resource structure of money and people. This is no small undertaking; cost estimates have fallen between ten and twenty million dollars. There seems to be a consensus that we must project an effort of this magnitude if we are to accomplish our stated and necessary goals.

The Tripartite Committee, comprised of the presidents and a board member from each of the three participating organizations — Engineers Joint Council, United Engineering Trustees, and the Engineering Index — will merge resources and create an entity which shall insure practicality and responsibility in the accomplishment of this major task.

One substantial resource which, regretably, did not receive attention here is in the form of reports from the managers of leading information centers across the country. This group, a Managers' Panel, has worked this past summer to prepare for EJC and the Tripartite Committee their recommendations of essential elements for a United Engineering Information Center and Network. EJC will publish these reports early in 1966.

There is clear recognition of the need for the engineering community to coordinate its activities with those of the federal government. Complementary values of the non-federal and federal complex have been partially realized in joint meetings with the Committee on Scientific and Technical Information (COSATI) of the Federal Council for Science and Technology.

The value of information in relation to cost appears to be a necessary control element upon the effectiveness of information systems. The consensus that the proposed United Engineering Information Center should be self-supporting is consistent with this concept.

Numerous references have been made to the need for user research. The Research Associate Program of the American Society for Metals and the program of the Engineering Index indicate a clear recognition by both organizations of the need for continuing user research.

The role of the engineering societies in a national information system (1) consists of six general areas of responsibility:

First, to reflect resources and knowledge available from their members and society organization functions.

A second major responsibility is the development of a coordinated Engineering Information Network System correlated to the United Engineering Information Center to be located in New York.

Third, the societies should make a systematic and intensive study of means through which the critical review of available information can improve validity and quality of information. Hence the corollary, to develop authoritative state-of-the-art reports and handbooks.

Fourth, information services and activities now provided by companies, groups and individuals within a society should be coordinated.

Fifth, these services of each society should be coordinated within the emerging national information system with services in other areas of knowledge such as physics and life sciences, which compose the elements of the national plan discussed in this symposium.

And, finally, as a sixth general area, the engineering societies should accept responsibility for problem definition and coordination of research into the techniques and philosophies of information retrieval and handling within the area of engineering.

The general plans discussed at this symposium provide a worthwhile pragmatic approach to the engineering information problem. It is clear that these preliminary, pragmatic solutions will be followed by far more advanced solutions related to, but reaching beyond, presently known techniques.

Reference

(1) N. E. Cottrell "The Role of the Engineering Societies in a National Information System." Engineers Joint Council, August 1965.

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